MAY 29 1946

Science Library

Volume 36 *Number 5*

Phytopathology

AN INTERNATIONAL JOURNAL

May 1946

Official Organ of

The American Phytopathological Society

$6.25 per year, Canada $6.00 per year, United States and dependencies $6.50 per year, elsewhere

Office of Publication

Corner North Queen Street and McGovern Avenue, Lancaster, Pennsylvania

Entered at the postoffice in Lancaster, Pennsylvania, as second-class matter.

TABLE OF CONTENTS

Albert Edward Edgecombe, 1897–1945 ..... Lewis Hanford Tiffany 327

Certain aspects of the epiphytology and control of tomato fruit rot caused by Phytophthora capsici Leonian.
W. A. Kreutzer and L. R. Bryant 329

Host-parasite relationships of the root-knot nematode, Heterodera marioni. II. Some effects of the host on the parasite.
Jesse R. Christie 340

Temperature effects on the expression of the yellows virus in sour cherries ..... W. D. Mills 353

Mosaics of winter oats induced by soil-borne viruses.
H. H. McKinney 359

Powdery mildew of broad bean caused by Erysiphe polygoni DC in Yunnan, China ..... T. F. Yu 370

Phytopathological Notes 379

Perithecia of powdery mildew on zinnia seed.
Kenneth F. Baker and Warren F. Locke

Camellia flower blight ..... H. Earl Thomas and H. N. Hansen

Yellow berry and stem rust of wheat ..... Gershon Minz

Physiologic races of yellow rust of raspberries in Western Washington ..... Folke Johnson

The relation of stomatal behavior at the time of inoculation to the severity of infection of soybeans by Xanthomonas phaseoli var. sojense (Hedges) (Starr) Burk.
William B. Allington and Carl V. Feaster

Reaction of dodders to stems of other dodders and to their own stems ..... C. F. Lackey

Infection studies with Actinomyces scabies.
W. J. Hooker and G. C. Kent

Late blight of tomatoes in East Texas at transplanting time.
P. A. Young

The eradicant action of a fungicide on Colletotrichum lilii in lily bulbs ..... F. J. LeBeau

Abstracts of papers accepted for presentation at the thirty-seventh annual meeting of the Society, St. Louis, Missouri, March 27 to 30, 1946 394

PHYTOPATHOLOGY

An International Journal
Official Organ of The American Phytopathological Society

EDITORS

HELEN HART, Editor-in-Chief, University Farm, St. Paul 8, Minnesota.
W. H. BURKHOLDER, Cornell University, Ithaca, New York.
A. J. RIKER, University of Wisconsin, Madison 3, Wisconsin.
W. J. ZAUMEYER, Bureau of Plant Industry Station, Beltsville, Maryland.

ASSOCIATE EDITORS

E. J. ANDERSON, State College of Washington, Pullman, Washington.
L. M. BLACK, Rockefeller Institute for Medical Research, Princeton, New Jersey.
A. A. DUNLAP, Agricultural Experiment Station, College Station, Texas.
M. W. GARDNER, University of California, Berkeley 4, California.
J. M. HAMILTON, N. Y. Agricultural Experiment Station, Geneva, New York.
F. L. HOWARD, Rhode Island State College, Kingston, Rhode Island.
W. G. HOYMAN, North Dakota State College, Fargo, North Dakota.
G. C. KENT, Iowa State College, Ames, Iowa.
H. N. RACICOT, Experimental Farm, Ottawa, Ontario, Canada.
L. R. TEHON, State Natural History Survey, Urbana, Illinois.
C. M. TUCKER, University of Missouri, Columbia, Missouri.
W. W. WAGENER, 720 Appraisers Building, San Francisco 11, California.

BUSINESS MANAGEMENT

R. M. CALDWELL, Business Manager, Purdue University, West Layfette, Indiana.
PAUL E. TILFORD, Advertising Manager, Agricultural Experiment Station, Wooster, Ohio.

NOTICES

All communications regarding subscriptions and back numbers should be sent to R. M. CALDWELL, Business Manager, A.E.S. Bldg., Purdue University, Layfette, Indiana.

Subscription price. $6.00 per year United States and dependencies; Canada, $6.25; other countries $6.50; single numbers of the current volume, 60 cents each. The journal has been issued monthly beginning with Volume VIII, January, 1918. Prior to that it was issued bimonthly.

Separate Numbers may be purchased from broken volumes, and stocks available are as follows: Vol. 1, No. 1, index; Vol. 2, Nos. 1, 5, index; Vol. 3, No. 5; Vol. 6, index; Vol. 8, Nos. 2, 3, 5, 6, 7, and 9 through 12; Vol. 9, Nos. 2 through 12, index; Vol. 10, Nos. 2 through 12. Separate numbers of volumes 1 through 10 are sold at $2.00 per copy, those of volumes 11 through 35 at $1.00 a copy. Complete, unbound volumes 11 through 35 are available at $8.00 a volume.

Thirty-Year Index (to Vols. 1–30, 1911–1940) bound. $5.50, United States. $6.00, elsewhere.

Advertisements. Rates may be secured from the Advertising Manager. No indorsement of any statement of claims made in advertisement is assumed by this journal or by The American Phytopathological Society.

Lost Numbers. Claims for copies (domestic subscriptions) lost in the mails must be received within 30 days from the date of issue (Jan. 15 and monthly thereafter); otherwise the usual charge of 60¢ per copy will be made for replacements. Deliveries overseas are not guaranteed for the duration of the war and foreign mailings are made at the subscriber's risk.

Restoration to Active Membership. Restoration requires no special action. No penality is imposed and no back dues are required. Application for reinstatement accompanied by check or money order for the current dues ($5) should be sent to the secretary. All issues of Phytopathology for the year will be supplied. Back volumes may be purchased, as far as available, at $8 each.

The American Phytopathological Society

FOUNDED 1909. INCORPORATED 1915

The A. P. S. Council for 1945

President—H. B. Humphrey, Box 14, Cosmos Club, Washington 5, D. C.

Vice-President—J. H. Graigie, Dominion Rust Research Laboratory, Univ. of Manitoba, Winnipeg, Manitoba, Canada

Secretary—E. M. Johnson, Agricultural Experiment Station, Lexington 29, Kentucky

Treasurer—R. M. Caldwell, Dept. Botany and Plant Pathology, Purdue University, Layfayette, Indiana

Editor-in-Chief—Helen Hart, University Farm, St. Paul 8, Minnesota

Councilors:

C. H. Arndt, Agricultural Experiment Station, Clemson College, South Carolina

R. J. Haskell, Extension Service, U. S. Dept. Agr., Washington 25, D. C.

M. C. Richards, University of New Hampshire, Durham, N. H.

R. S. Kirby, Pa. State College, State College, Pennsylvania

R. W. Goss, Dept. Plant Pathology, College of Agriculture, Lincoln 1, Nebraska

L. D. Leach, Div. Plant Pathology, University Farm, Davis, California

J. J. Christensen, Div. Plant Pathology, University Farm, St. Paul 8, Minnesota

Sustaining Contributors:

Rohm and Haas, Washington Square, Philadelphia 5, Pennsylvania

E. I. du Pont de Nemours & Company, Wilmington 98, Delaware

Freeport Sulphur Company, New Orleans 5, Louisiana

Tennessee Corporation, 619–27 Grant Building, Atlanta 1, Georgia.

DIFCO

Culture Media for Fungi

This group of Dehydrated Culture Media, Difco, is prepared expressly for propagation of the fungi most frequently encountered in phytopathological studies. Each medium is readily prepared for use and requires no adjustment of its reaction or filtration of the solution.

Bacto-Bean Pod Agar
Bacto-Corn Meal Agar
Bacto-Lima Bean Agar
Bacto-Malt Agar
Bacto-Potato Dextrose Agar
Bacto-Prune Agar
Bacto-Wort Agar
Bacto-Malt Extract Broth

The Difco Manual, 7th Edition, containing discussions of our extensive line of Dehydrated Culture Media and Ingredients of Culture Media, is available on request.

Specify "DIFCO"

DIFCO LABORATORIES
INCORPORATED
DETROIT 1, MICHIGAN

ALBERT EDWARD EDGECOMBE

1897–1945

LEWIS HANFORD TIFFANY

The sudden death on March 30, 1945, of Professor Albert Edward Edgecombe at the age of forty-eight cut short the life of a man whose devotion to study and research had reached the stage where his accumulated knowledge and techniques would have resulted in maximal productiveness. He was an Englishman by birth, spent over half of his life in Canada, and became an American citizen in 1935. He was an associate professor of botany at Northwestern University at the time of his death. His research activities were largely in the field of mycology.

Edgecombe was born in Devonshire, England, on February 5, 1897, and succumbed to a cerebral hemorrhage at Wilmette, Illinois, on March 30, 1945. He taught for eight years in the high schools of Canada and served for a time as a field agent of the Presbyterian Church in both Alberta and British Columbia. He entered Queen's University, Ontario, in 1921 and obtained the A.B. degree with honors in botany in 1923. In 1925 he was granted the M.A. degree from Queen's with a thesis on the rise of sap in woody plants. He was appointed to a graduate fellowship in botany at the University of Chicago in 1926 and received the Ph.D. from that institution in 1929. For his doctoral dissertation, prepared under the direction of Professor George K. K. Link, he investigated immunological relationships of certain wheats resistant and susceptible to rusts. He received the LL.B. and J.D. degrees from the Chicago Law School in 1934.

Dr. Edgecombe served as an assistant professor of botany at Northwestern University from 1929 to 1939, and as associate professor from 1939 until his death. He taught, at various times, general botany, plant genetics, mycology, plant pathology, and bacteriology. His special interests lay, however, in mycology and plant pathology, and recently he had made considerable study of certain dermatophytic fungi. He had worked on the mycetozoan flora of the Chicago Region for many years. His repeated attempts to culture certain of the obligate rusts on artificial media gave uniformly negative results. Post-doctoral studies in plant pathology, mycology, immunology, and medicine were made at Cornell University, University of Michigan, Pennsylvania State College, the Gradwohl Laboratories at St. Louis, and the Presbyterian Hospital of Columbia University.

Professor Edgecombe became a fellow of the American Association for the Advancement of Science in 1931 and was a charter member of the Mycological Society of America. In addition, he held membership in the American Phytopathological Society, Botanical Society of America, American Association of University Professors, Illinois Academy of Science, Sigma Xi, and Phi Alpha Delta. He married Sara Roberta Mohn of Pottstown, Penn-

ALBERT EDWARD EDGECOMBE
1897–1945

sylvania, on November 23, 1939. His widow and two children, Phyllis and David, together with one brother living in Canada, survive him.

Edgecombe was retiring, shy, and modest to the point of self-effacement. His qualities of friendliness, generosity, and affection were reserved for his family and his intimate friends. He loved the quiet of his home and the seclusion of his laboratory. He was an indefatigable worker, his interests ranged from poetry to medicine, and he died as he had wanted to live: quietly and with a minimum of disturbance to his fellow man.

Dr. Edgecombe was the author of the following publications:

Further agglutination tests with phytopathogenic bacteria (with G. K. K. LINK and J. GODKIN). Bot. Gaz. **87**: 531–547. 1929.

Immunological relationships of wheats resistant and susceptible to Puccinia rubigo-vera triticina. Bot. Gaz. **91**: 1–21. 1931.

A comparative study of certain fungi. Trans. Ill. State Acad. Sci. **30**: 108–110. 1937.

Differential distribution of ash along the axis of herbaceous plants. Trans. Ill. State Acad. Sci. **32**: 79. 1939.

Differential distribution of ash in stems of herbaceous plants from base to tip. Amer. Jour. Bot. **26**: 324–328. 1939.

The growth rate of several wood-inhabiting fungi. Phytopath. **31**: 825–831. 1941.

Trichophyton purpureum (Bang) and Trichophyton gypseum (Bodin). Archives of Dermatol. and Syphilol. **46**: 651–660. 1942.

CERTAIN ASPECTS OF THE EPIPHYTOLOGY AND CONTROL OF TOMATO FRUIT ROT CAUSED BY PHYTOPHTHORA CAPSICI LEONIAN[1]

W. A. KREUTZER AND L. R. BRYANT[2]

(Accepted for publication December 17, 1945)

INTRODUCTION

Since 1930 serious sporadic losses in certain truck crops in Colorado have been caused by *Phytophthora capsici* Leonian. This organism has been responsible for field losses in the State in peppers (*Capsicum annuum* L.) and eggplants (*Solanum melongena* L. var. *esculentum* Nees) (1), cucumber fruits (*Cucumis sativus* L.) (4), honeydew melon (*Cucumis melo* L. var. *inodorus* Naud.) and cantaloupe fruits (*Cucumis melo* L. var. *reticulatus* Naud.) (18), squash (*Cucurbita maxima* Duc.), watermelon vines (*Citrullus vulgaris* Schrad.) (5), watermelon fruits (19), and tomato fruits (*Lycopersicum esculentum* Mill.) (5). In addition, within the past two years the senior writer has isolated the organism from decaying fruits of banana squash (*Cucurbita maxima* Duc.) in northern Colorado fields.

Elsewhere in the United States, *Phytophthora capsici* has occurred in epiphytotic form in the field on pepper plants in New Mexico (9) and Florida (17), and in California on honeydew melon fruits (13). Fruit rot of tomatoes caused by both *P. capsici* and *P. drechsleri* was reported by Tompkins and Tucker (14) as occurring in California in 1937, 1938, and 1939. In this same publication a complete literature review on fruit rot of tomatoes and its causal agents is given. In addition, a root rot of pepper and pumpkin (*Cucurbita pepo* L.) caused by *P. capsici* has been described as occurring in the same State (15).

Fruit rot of tomatoes caused by *Phytophthora capsici* occurred in epiphytotic proportions in the Arkansas River Valley of Colorado in 1938 (5). In 1940 fruit rot of tomatoes occurred in northcentral Colorado in the Brighton area. Losses in each of the 1938 and 1940 epiphytotics in Colorado were estimated by canning companies to be approximately 50 per cent in those areas. In 1945, another outbreak of the disease in the Arkansas River Valley occurred. Losses were estimated at from 10 to 25 per cent.

Because of the high losses in these areas, a study was begun in 1942 to determine (a) the principal factors influencing the production of sporangia and swarmspores by the pathogen, (b) the effects of temperature and duration of exposure on infection of fruits by swarmspores, (c) the rôle of cultural practices or chemical treatments in the control of fruit rot in the field, and (d) the possibility of resistance in any commercial varieties, selections, hybrids, or types of tomatoes available.

[1] Paper No. 199, Scientific Journal Series, Colorado Agricultural Experiment Station.

[2] The writers wish to express their appreciation to Mr. George H. Lane, Dr. A. O. Simonds, Mr. W. C. Hatfield, and Dr. L. W. Durrell, for assistance during certain phases of this study. They also wish to acknowledge the assistance of other members of the staff of the Colorado Agricultural Experiment Station in the course of the work.

EXPERIMENTAL RESULTS

Sporulation and Infection by Phytophthora capsici

From both field observations and experimental work, it is indicated that epiphytotics of tomato fruit rot caused by *Phytophthora capsici* depend primarily on sporangium and swarmspore formation (7). Accordingly, before control measures could be developed and evaluated it seemed necessary to determine the conditions under which the causal organism would produce sporangia and swarmspores, and the factors influencing fruit infection by swarmspores.

In this study two isolates were used. Culture 5C was obtained from rotting tomato fruits in northcentral Colorado, and culture 6C was obtained from fruits growing in southeastern Colorado. These isolates were morphologically similar to other previously identified cultures obtained in the State (5, 6). All isolates of the organism have been virulently pathogenic to nonwounded pepper plants (*Capsicum annuum* L.). With the exception that local isolates either form no sexual fruiting bodies or produce them only after 6 to 8 months in culture, they conform with the adequate descriptions of *Phytophthora capsici* (9, 13, 15, 16, 19).

Formation of Sporangia and Swarmspores.—In previous studies by the writers (7), local isolates readily produced abundant sporangia when nonsteamed field soil was used as a medium for their development. The optimum temperature range for the growth of certain isolates of *Phytophthora capsici* has been given by Godoy (3) as 24° to 26° C. Tompkins and Tucker (13) found the optimum growth range for one isolate to be 25° to 30° C. Wiant and Tucker (19) reported the optimum temperature range for growth of another isolate to be 26.7° to 29.4° C. Kreutzer *et al.* (6) found that the optimum temperature for sporangium production of certain isolates of *P. capsici* obtained from wilted pepper plants and rotted cucumber fruits was near 30° C.

To determine the optimum temperature for sporangium production using nonsteamed field soil as a medium, giant cultures on barley were ground and mixed with approximately five times as much nonsteamed field soil by volume. The soil was treated as in previous studies (7) except that the moistened soil-inoculum mixture was placed in clay pots and incubated at 10°, 15°, 20°, 25°, 30°, and 35° C. at 100 per cent relative humidity for from 48 to 64 hours. The determination of the presence and relative quantity of sporangia was made using a previously described technique (7), placing one cubic inch of the soil mixture in a 400-ml. beaker containing approximately 30 ml. of tap water, allowing this mixture to stand at 25° C. for from 2 to 4 hours, and then examining drops for the presence and relative numbers of swarmspores at hourly intervals within that period.

Sporangia were produced only at temperatures ranging from 20° to 30° C. inclusive, the greatest quantity being produced at 25° C. No sporangia were produced at 10°, 15°, or 35° C. In other similar trials results were

essentially the same. Another important point was brought out in subsequent tests; while sporangia were produced at 20° C., none were formed at a controlled temperature of 18° C.

The 2- to 4-hour period used to determine the relative numbers of swarmspores produced was the result of trials which, in general, showed that at

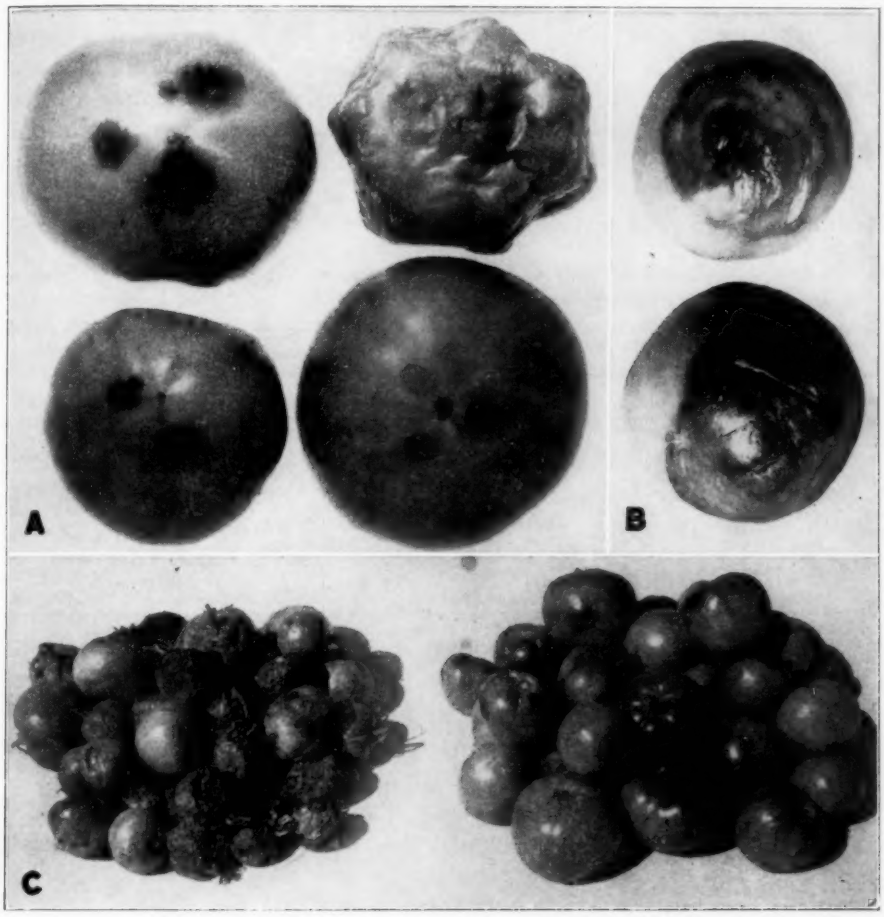

FIG. 1. Fruit rot of tomatoes caused by *Phytophthora capsici*. A. Technique used to test infectivity of *P. capsici* under varying conditions. Lower right: drops containing swarmspores on uninjured fruit surface. The other three fruits show progressive stages in infection at 3-day, 6-day, and 14-day intervals at room temperatures. B. Two types of fruit-rot symptoms. C. The yield of a single plant showing loss caused by the disease. Left, fruits which were in contact with the soil. Right, fruits which were not in contact with the soil.

25° C. only a few swarmspores were released in 90 minutes, while after 150 minutes swarmspores were abundant. In most cases swarmspore production was apparent in from 30 to 60 minutes and reached its peak in from 2 to 3 hours.

Swarmspore Germination and Infection.—The rôle of temperature and time in the germination of and infection by swarmspores was determined.

In one study the effect of time exposure on infection at varying temperatures was investigated. Green fruits[3] of the Landreth variety were inoculated by placing two to three drops of inoculum containing numerous active swarmspores on the stylar ends (Fig. 1, A). They were then incubated at 20°, 25°, and 30° C. at 100 per cent relative humidity for 40, 60, 80, 100, 120, 140, 160, and 180 minutes. Ten inoculated fruits were used for each time exposure at each given temperature. At the end of each time interval, fruits were removed from the incubators and the drops of inoculum were removed by gentle blotting with clean cheesecloths. These fruits were then placed on laboratory tables at room temperatures. Fruits were examined at 12-hour intervals for 6 days. At the end of this period final readings were made. In figure 1, A are typical reactions to inoculation by use of this technique. The results of this study, with isolates 5C and 6C, are in table 1.

TABLE 1.—*Effect of time of exposure at varying temperatures on infection of tomato fruit (variety Landreth) by Phytophthora capsici*

Exposure (minutes)	Percentage of inoculated areas infected at		
	20° C.	25° C.	30° C.
40	0.0	0.0	0.0
60	0.0	10.0	15.0
80	10.0	35.0	45.0
100	40.0	85.0	65.0
120	70.0	85.0	85.0
140	75.0	90.0	80.0
160	60.0	60.0	90.0
180	90.0	100.0	100.0

The earliest infection observed occurred after exposure for 60 minutes at 25° and 30° C. No infection was noted at 20° C. until exposure was increased to 80 minutes. Infection at 20° C. was consistently less than at 25° C. and 30° C. except after the longer exposures. Temperatures of 25° C. and 30° C. were equally effective at all exposure periods tested.

In a number of parallel tests the results were similar to those given in table 1. In no instance was infection observed after exposure of less than 60 minutes at any temperature and in no case was infection observed at less than 80 minutes exposure at 20° C.

In other studies, exposures of fruit to swarmspore inoculum at 10° C. brought about infection. In these tests fruits were exposed to drops of inoculum for 5 hours at 10°, 15°, and 20° C. All fruits were infected. No attempt was made to determine the shortest exposure time for infection at 10° C.

In another trial a total of 910 green fruits of uniform size from 40 varieties, lines, and types of tomatoes were used. The fruits were first randomized on clean laboratory tables and held for 24 hours at room temperatures to equalize all fruit temperatures. They were then inoculated by placing

[3] Green fruits were used in all tests rather than red or ripening fruits, since infection in its earliest stages was more readily detected on green fruits.

3 drops of water containing active swarmspores of culture 6C on the stylar end without injury to the fruit. The drops were allowed to dry naturally, and the drying time was recorded for individual fruits. Drying intervals fell within a range of 40 to 170 minutes. The fruits were placed in classes of 20-minute intervals, giving 6 class intervals of 40–59, 60–79, 80–99, 100–119, 120–139, and 140–169 minutes. During the trials, thermometers were placed in check fruits at random on the tables to obtain temperature variations. A recording of infections was made 10 days after the time of inoculation. The results are in table 2.

The drops on the majority of fruits (506 cases) dried in from 60 to 99 minutes. The earliest infection, together with the smallest number of infected fruits (5.0 per cent), was observed in the 60–79-minute interval. The greatest amount of infection (72.7 per cent) appeared in the 140–169-minute interval.

TABLE 2.—*Effect of time of exposure on infection of tomato fruits by Phytophthora capsici at room temperature (22–24° C.)*

Time interval (minutes)	Total number of fruits inoculated	Percentage of fruits infected
40–59	58	0.0
60–79	261	5.0
80–99	245	23.7
100–119	191	48.1
120–139	111	57.6
140–169	44	72.7

Another series of studies was designed primarily to determine the degree of swarmspore activity and compare it with infection at varying time intervals. Temperatures were held uniform at 25° C. and the same techniques were used as in previous tests except that the drops of swarmspore-inoculum on fruits were washed off with 95 per cent ethyl alcohol after each lot of fruit was removed from the incubator at a given time interval. In addition, to determine swarmspore activity and germination at each time interval, several inverted drops of swarmspore inoculum on slides mounted on glass blocks in Petri dishes were placed in the incubator for each inoculated lot of fruits. The drops were examined for swarmspore activity and germination when each lot of fruits was removed from the incubator. The results of this study are in table 3.

Quiescent swarmspores were first noted at 80 minutes, and the earliest germination occurred in 100 minutes. This correlates perfectly with the shortest time at which infection was observed. At 140 minutes, a few swarmspores still were active, but at 160 minutes all activity had ceased. Inoculated fruits were washed with alcohol at the end of each exposure interval and blotted as in previous tests. This disinfectant undoubtedly destroyed all spores on the fruit surface and all germ tubes which were not established within the cuticle. This may explain the comparatively long time interval required for infection (100 minutes) as against a shorter period of 80 minutes for previous tests.

TABLE 3.—*Effect of time of exposure at 25° C. on swarmspore activity and germination, and infection of Landreth tomato fruit by swarmspores*

Exposure (minutes)	Observations on swarmspores	Infection of inoculated fruits
20	All swarmspores very active.	–
40	All swarmspores active.	–
60	Swarmspores less active.	–
80	A few swarmspores quiescent, majority still active.	–
100	Majority of swarmspores quiescent, a few germinating.	+
120	Majority of swarmspores germinating.	+
140	Almost all swarmspores quiescent, germination general.	+
160	All swarmspores quiescent, germination marked.	+
180	Almost all swarmspores germinating.	+

Control Investigations

Since sporangia apparently are not formed at 18° C. (64.4° F.) or below, an epiphytotic of fruit rot should not occur at such temperatures even though abundant moisture is present. Observations in commercial tomato fields in canning districts support this view. However, with favorable temperatures for sporangium production (above 20° C.) and abundant free water, sporangia will form rapidly within 24 to 48 hours, and swarmspores will be released in from 1 to 3 hours. Following the release of swarmspores infection can occur at any field temperature, and at favorable temperatures of 25° to 30° C. can occur in as short a time as 60 minutes. These findings emphasize that for effective prevention of tomato-fruit rot, control measures should be applied before conditions favor an epiphytotic.

Use of Cultural Methods.—In 1942 a study was conducted to determine if mulching the bases of plants with straw would aid in reducing infection caused by *Phytophthora capsici*. In two 160-foot rows of a plot in which the soil was inoculated by the method described in an earlier paper (7), plants of both Landreth and Early Baltimore varieties were straw-mulched. Control plants left in small five-plant blocks were not mulched. Records were taken on 1,827 fruits, from 30 plants. The results are in table 4.

Although the design of the 1942 test was such that the data obtained were unsuited for statistical analysis, the wide differences in results between the mulched plants (93.8 and 83.5 per cent healthy fruits) and the nonmulched plants (42.2 and 29.5 per cent healthy fruits) indicate that mulching reduced fruit rot to a marked degree.

TABLE 4.—*Effect of straw mulching on field infection of fruits of the Landreth and Early Baltimore varieties of tomato*

Variety	Percentage of healthy tomato fruits from	
	Mulched plants	Nonmulched plants
Early Baltimore	93.8	42.2
Landreth	83.5	29.5
Total	88.6	36.0

In 1943 staking and low ridging (6 inches) were included with mulching in another field experiment. Staking tomato plants was recommended by Sherbakoff (11) as a possible control for Buckeye rot of tomato caused by *Phytophthora terrestria* (*P. parasitica*). Sherbakoff, however, had no experimental staking trials. In the test conducted by the writers, 120 plants of the Landreth variety were set out in a randomized block of 12 plots. Each treatment was replicated three times. The soil was inoculated by the soil-inoculum method (7) and irrigated at frequent intervals. At harvest, all plants were stripped of fruit. Readings were made on 5,509 individual fruits. The results are in table 5.

Ridging resulted in significantly[4] more healthy fruits than the control. In mulched and staked plots, the increases in healthy fruits over the control were highly significant, and an increase in yield of healthy fruits approach-

TABLE 5.—*Effect of cultural treatments for the reduction of tomato fruit rot. Results are given as three-plot averages of healthy fruits harvested*

Treatment	Average percentage of healthy fruits	
	Actual	Transformed[a]
Control	60.53	51.12
Ridging	80.78	65.00
Mulching	89.42	71.13
Staking	98.05	82.46
Difference required for significance 5 per cent level = 12.09		
Difference required for significance 1 per cent level = 18.31		

[a] Percentages converted into $\sin^2 \theta$ by use of Bliss's tables (2, 8).

ing the 1 per cent level of significance was obtained in staked plots when compared with that obtained by ridging.

Use of Dust Fungicides.—Because fruit rot appears in commercial tomato fields late in the season, the large sprawling vines make spraying or dusting with power equipment an impractical undertaking, and few growers or canning companies are interested in hand spraying. Dusting by hand, however, is considered practical and is frequently employed in Colorado late in the season to control certain insects. For these reasons, the effectiveness of various fungicidal dusts in controlling tomato fruit rot was determined.

As a preliminary to field trials, an investigation was conducted in the laboratory using fruits grown in the greenhouse. A method was devised to give a rough approximation of the fungicidal value of any dust. Fruits to be tested were individually mounted on watchglasses and then were given a light dusting with a fungicide. Following this they were inoculated by sprinkling lightly with drops of water containing motile swarmspores of *Phytophthora capsici*. The inoculated fruits were placed in incubators at 25° C. at 100 per cent humidity or in moist chambers at room temperatures

[4] Where "significant" is used, it refers to the 5 per cent level of significance. "Highly significant" refers to the 1 per cent level of significance.

for from 2 to 4 hours. At the end of this time the fruits were removed and the drops dried by blotting. The fruits were then held on laboratory tables to determine whether infection would develop.

The most effective fungicides used were those which contained copper as the active principal. Dusts selected for field testing were 5 and 10 per cent Yellow Cuprocide, 10 per cent Basicop, 10 per cent tribasic copper sulphate, and 10 per cent copper oxychloride. Bordeaux spray (4–4–50) was included in the test as a fungicidal standard. To test the efficacy of these chemicals in the field, a planting of tomato plants of the Landreth variety was divided into three blocks, each containing eight randomized plots (Table 6). The treatments were next applied and the soil of the plots was inoculated using the soil-inoculum technique (7). Frequent irrigations and the occasional use of a system of overhead sprinklers kept the field wet for 10 days. At the end of this time the treatments were again applied to the plots and were followed by a light sprinkling. The planting consisted of 24 plots containing 240 plants. The fruits on 238 plants were counted and read for disease. Fruits were divided on the basis of whether they were in contact with the ground or above the ground (Fig. 1, C). Fruits resting on fruits in contact with the ground were considered in the ground-contact group. A total of 11,385 fruits were recorded on the basis of health or rot; 5,348 of these were in contact with the ground and 6,037 were above the ground. Readings were made 30 days after the inoculation. The results are in table 6.

Analysis of transformed data (2, 8) given in table 6 indicates that where fruits were in contact with the ground, all treatments except Nos. 4 (10 per cent Basicop) and 5 (10 per cent tribasic copper sulphate) gave a highly significant control when compared with the untreated check (No. 8). The percentage differences between treatments 4 and 5 and the control were nonsignificant.

Where only fruits above the ground are considered, one treatment, No. 2 (5 per cent Yellow Cuprocide + talc), gave significantly more healthy fruit than the control.

If fruit totals are considered, irrespective of position on the plant, all treatments except Nos. 4 (10 per cent Basicop), 5 (10 per cent tribasic copper sulphate), and 3 (10 per cent Yellow Cuprocide), gave highly significant increases in healthy fruit over the control. Treatment No. 3 (10 per cent Yellow Cuprocide) was significantly better than the control. The differences between treatments 4 and 5 and the control were not significant.

Use of Copper Sulphate in Irrigation Water.—Muller (10), who made his observations in the Netherlands East Indies on a foot rot of black pepper (*Piper nigrum* L.), recommended the use of a network of shallow drain trenches to prevent infection by *Phytophthora palmivora* var. *piperis*. When infection occurred in one of the squares isolated by trenches, Muller recommended that the diseased plants be watered with 5 to 10 liters of a 1 per cent solution of copper sulphate per square meter to prevent spread of the disease.

TABLE 6.—*Effect of chemical treatments for the control of tomato fruit rot on the Landreth variety, 1943. Results are given as three-plot averages of percentages of healthy fruits*

No.	Treatment	Average percentages of healthy fruit					
		On ground		Above ground		Total	
		Actual	Transformed[a]	Actual	Transformed	Actual	Transformed
1	5 per cent Yellow Cuprocide, 95 per cent Cherokee clay, dust	60.71	51.43	98.58	83.96	82.10	65.30
2	5 per cent Yellow Cuprocide, 95 per cent talc, dust	65.48	54.32	99.14	85.65	83.60	66.26
3	10 per cent Yellow Cuprocide, 90 per cent talc, dust	59.11	50.28	97.60	81.55	77.82	62.00
4	10 per cent Basicop, 90 per cent talc, dust	48.04	43.87	97.48	81.01	72.69	58.57
5	10 per cent tribasic copper sulphate, 90 per cent talc, dust	42.67	40.73	98.11	82.45	71.93	58.17
6	10 per cent copper oxychloride, 90 per cent talc, dust	63.59	52.97	98.36	82.69	82.37	65.38
7	4–4–50 Bordeaux mixture, spray	70.38	57.15	98.52	83.48	83.17	66.02
8	Control, no treatment	32.03	34.18	95.37	78.71	65.43	54.05
Difference required for significance:							
	5 per cent level		11.32		6.23		7.74
	1 per cent level		15.71		8.64		10.74

[a] Actual percentages transformed to values of p as $\sin^2$ of θ by use of Bliss's tables (2, 8).

In a preliminary trial in 1944, to determine the value of $CuSO_4$ in irrigation water as a control for *Phytophthora capsici*, a small plot was planted with tomatoes of the Landreth variety. Inoculation of the soil was begun during cool weather (September 7) since fruit development had been very late. A total of eight 135-foot rows were used in the study. Each of four rows was treated with 5½ pounds of $CuSO_4$ and four rows were held

TABLE 7.—*Effect of the addition of copper sulphate to irrigation water for the control of tomato fruit rot. Results are given as four-plot averages of healthy fruits harvested*

Treatment of irrigation water	Average percentage of healthy fruits	
	Actual	Transformed
$CuSO_4$ added to irrigation water at rate of approximately 4 pounds per 100 feet of row	97.46	81.42
Control, no $CuSO_4$ added to irrigation water	89.94	71.73
Diff. required for significance at 5 per cent level		5.61
Diff. required for significance at 1 per cent level		9.30

as controls. Copper sulphate treated and control rows were separated by two-row buffers. The fruit on the first 10 plants of each row were harvested and read for disease. A total of 80 plants bearing 11,040 fruits were read. The results are in table 7.

The data show a highly significant increase in the average percentage of healthy fruits harvested in favor of the $CuSO_4$-treated lots. The actual average percentage of healthy fruit harvested for the control plots, 89.94, is a very high figure, indicating only light infection.

Resistance to Tomato Fruit Rot.—Of all the commercial varieties of tomatoes tested to date for resistance to tomato fruit rot, none have shown any consistently resistant reactions. In 1942, 120 commercial varieties, lines, and types were tested in the field in small blocks. Only a few of these lines showed any promise. Although not very consistent in its reactions, the variety Porter apparently has some resistance.

The fruits of all plants being tested are subjected to a laboratory test. All fruits are inoculated by placing drops of water containing swarmspores on their noninjured stylar ends. The stylar end is subjected to infection because fruits generally appear to be more resistant to infection at the calyx end (12). Fruits are then incubated and treated as previously described. Only those having definitely arrested lesions are considered resistant. These studies have not progressed to the point where any definite statements regarding resistance can be made.

SUMMARY

Cultures of *Phytophthora capsici* isolated from rotting tomato fruits formed sporangia in great abundance within 48 hours at 25° C., when 20- to 60-day-old giant barley cultures were ground and mixed with well-moistened, nonsteamed field soil.

The optimum temperature for sporangium development by these isolates was about 25° C. Sporangia were not produced at 18° C. or lower temperatures, but occurred readily between 20° and 30° C. Sporangia were not produced at 35° C. Although abundant moisture is an essential factor, the prime requisite for an epiphytotic is a soil temperature between 65° and 85° F.

When water was added to soil-inoculum that had been held at 25° C. for 48 hours swarmspore production reached its peak in from 2 to 3 hours at 25° C.

Earliest infection of noninjured green tomato fruits occurred after 60-minute exposure to drops of inoculum containing swarmspores, at 25° and 30° C. Infection reached its peak after 180-minute exposure at 25° and 30° C. Exposure of fruits to swarmspores at 10° C. for 5 hours resulted in infection. Studies of swarmspore activity showed that the time required to produce infection was correlated with the time required for swarmspore germination.

The rapidity of sporangium formation at optimum temperatures and the

release and germination of swarmspores indicate that control measures must be applied early if they are to be effective.

Tests on cultural practices for the control of fruit rot showed that mulching with straw or staking resulted in more healthy fruit than corresponding controls (1 per cent level of significance). Ridging produced significantly more healthy fruit than the controls (5 per cent level of significance).

Studies on the use of fungicidal dusts for the control of fruit rot showed that where fruits in contact with the ground were considered, 5 per cent and 10 per cent cuprous oxide and 10 per cent copper oxychloride gave highly significant (1 per cent level) control. Bordeaux spray 4–4–50 also effectively controlled the disease.

Preliminary studies on the addition of $CuSO_4$ to irrigation water at the time of soil inoculation, indicated a highly significant degree of control.

Of 120 commercial varieties, lines, and types of tomato tested in the field, a few lines have shown slight promise in resistance studies.

COLORADO AGRICULTURAL EXPERIMENT STATION,
FORT COLLINS, COLORADO.

LITERATURE CITED

1. BODINE, E. W. Blight of peppers. Colo. Agr. Exp. Stat. Press Bul. 85. 1935.
2. CLARK, ANDREW, and WARREN H. LEONARD. The analysis of variance with special reference to data expressed as percentages. Jour. Amer. Soc. Agron. 31: 55–66. 1939.
3. GODOY, ERNESTO F. El "mildew" o "tizón" del pimiento producido por la "Phytophthora capsici" en La República Argentina. La Plata Univ. Nac., Facultad de Agron. Rev. 24: 235–280. 1940.
4. KREUTZER, W. A. A Phytophthora rot of cucumber fruit. (Abstr.) Phytopath. 27: 955. 1937.
5. ———, E. W. BODINE, and L. W. DURRELL. Cucurbit diseases and rot of tomato fruit caused by *Phytophthora capsici*. Phytopath. 30: 972–976. 1940.
6. ———, ———, and ———. A sexual phenomenon exhibited by certain isolates of *Phytophthora capsici*. Phytopath. 30: 951–957. 1940.
7. ———, and L. R. BRYANT. A method of producing an epiphytotic of tomato fruit rot in the field. Phytopath. 34: 845–847. 1944.
8. LEONARD, WARREN H., and ANDREW G. CLARK. Field plot technique. 271 pp. Burgess Pub. Co. (Minneapolis, Minn.). 1939.
9. LEONIAN, LEON H. Stem and fruit blight of peppers caused by *Phytophthora capsici* sp. nov. Phytopath. 12: 401–408. 1922.
10. MULLER, H. R. A. Het Phytophthora-voetrot van Peper (*Piper nigrum* L.) in Nederlandsche-Indië. Meded. Inst. PlZiekt., Batavia. 88. 1936. (Abstr. in Rev. Appl. Mycol. 16: 559–560. 1937.)
11. SHERBAKOFF, C. D. Buckeye rot of tomato fruit. Phytopath. 7: 119–129. 1917.
12. SIMONDS, AUSTIN O., and W. A. KREUTZER. Infection phenomena in tomato fruit rot caused by *Phytophthora capsici*. Phytopath. 34: 813–817. 1944.
13. TOMPKINS, C. M., and C. M. TUCKER. Phytophthora rot of honeydew melon. Jour. Agr. Res. [U. S.] 54: 933–944. 1937.
14. ———, and ———. Buckeye rot of tomato in California. Jour. Agr. Res. [U. S.] 62: 467–474. 1941.
15. ———, and ———. Root rot of pepper and pumpkin caused by *Phytophthora capsici*. Jour. Agr. Res. [U. S.] 63: 417–426. 1941.
16. TUCKER, C. M. Taxonomy of the genus Phytophthora de Bary. Mo. Agr. Exp. Stat. Bul. 153. 1931.
17. WEBER, GEORGE F. Blight of peppers in Florida caused by *Phytophthora capsici*. Phytopath. 22: 775–780. 1932.
18. WIANT, JAMES S. Species of *Phytophthora* responsible for market decay of western Honey Dew melons and cantaloupes. U. S. Dept. Agr., Pl. Dis. Rptr. 23(19): 322. 1939.
19. ———, and C. M. TUCKER. A rot of Winter Queen watermelons caused by *Phytophthora capsici*. Jour. Agr. Res. [U. S.] 60: 73–88. 1940.

HOST–PARASITE RELATIONSHIPS OF THE ROOT–KNOT NEMATODE, HETERODERA MARIONI. II. SOME EFFECTS OF THE HOST ON THE PARASITE[1]

JESSE R. CHRISTIE

(Accepted for publication January 21, 1946)

The feasibility of growing a particular crop on land infested with the root-knot nematode, *Heterodera marioni* (Cornu) Goodey, depends, in most instances, on two factors: (a) The extent to which the crop in question will be injured and yield thereby reduced and (b) the amount of residual soil infestation that will carry over to infect the following crop. The first factor will be determined, primarily, by the effects of the parasite on the host and the second factor may be determined, to a considerable extent, by the effects of the host on the parasite. These effects of the host on the parasite become manifest in various ways, *e.g.*, by the rate at which the nematodes develop, by the extent to which they develop, by the percentage of females that reach maturity, and by the number of eggs laid by these females. However, these are not distinct and independent manifestations but are, to some extent, interdependent.

Development of the root-knot nematode is influenced, of course, by environmental factors other than the host, of which temperature seems to be the most important. Demonstrating the effect of this factor, Tyler (5) found that in tomato, grown in soil at 27° C., 16 to 19 days elapsed from the time larvae entered the roots until females began to lay eggs. When the plants were grown in soil at 24° C., this interval was 25 to 27 days, and at 15.5° C. it was 67 days. Demonstrating the effects of the host on parasite development, Godfrey and Oliveira (3) found that in cowpea, grown at a temperature permitting rapid development, the interval between penetration of larvae and first deposition of eggs was 19 days, but that in pineapple, grown under identical conditions, it was 35 days.

Using population 8 of the root-knot nematode (see Table 1) and growing the plants in a greenhouse where the temperature averaged slightly below optimum for rapid development of the parasite, the writer found that in common tobacco (*Nicotiana tabacum* L.) about 20 days usually elapsed from the time larvae entered the roots until females began to lay eggs. In turnip (*Brassica rapa* L.), grown under identical conditions, this interval was increased by 8 or 10 days but most of the females eventually reached maturity and egg output was not noticeably less than in common tobacco. In *Nicotiana megalosiphon* Heurck & Muell. Arg. development was much slower than in turnip, only a few females (probably less than 1 in 50) ever reached maturity and those that did laid much fewer eggs than in common tobacco. In *N. plumbaginifolia* Viv. development was retarded more than in *N. megalosiphon* and only a few parasites ever passed the molting stage.

[1] For the first paper of this series see literature cited (2).

A meticulous examination of the entire root system shown in figure 2 revealed only one egg-laying female, a translucent, ill-nourished individual about one-third normal size, that had deposited 7 eggs. In *Crotalaria spectabilis* Roth, development progressed even slower than in *N. plumbaginifolia* and no parasite was seen that had passed the molting stage. Larvae entered the roots of all these plants freely but with *C. spectabilis* moderately swollen root tips were about the only macroscopic evidence of infection. With *N. megalosiphon* and *N. plumbaginifolia*, on the other hand, galling was only slightly less conspicuous than with common tobacco (Fig. 2).[2] These differences in parasite development resulted from interactions between the same race of nematode and different host plants but it eventually became obvious that equally pronounced differences may result from interactions between different races of the parasite and the same host plant.

Reported in this paper are the results of several experiments to ascertain the effects of the host on the parasite, especially on rate and extent of development. Supplementing these experiments are the results of certain observations, demonstrating, to some extent, how these effects of the host on the parasite may influence the building up and maintenance of nematode populations.

PROCEDURE

One object of the procedure employed was to control or equalize, so far as possible, factors other than host that influence the development of the parasite. This was accomplished, at least to some degree, by so arranging the experiments that the various dates when the plants representing one host-parasite combination were infected corresponded approximately with the dates when the plants representing another host-parasite combination were infected; by growing the plants simultaneously in the greenhouse; and by securing data on a representative sample of the parasites harbored by each plant. Air temperatures in the greenhouse were 18° to 21° C. during the night and 24° to 27° C. during the day.

Nematode populations used. In the previous paper of this series (2) the term population was used to designate "an aggregate of individuals of the root-knot nematode the progenitors of which were secured from a single plant or from several plants of the same kind that grew together in the same locality." This use of the term is continued in the present paper. The manner by which the nematodes were collected does not preclude the possibility that a population includes more than one race but considerable work with these populations has failed to produce any very convincing evidence that such is the case. However, methods for identifying and differentiating races have not been perfected. The differences between some races are very pronounced and easy to demonstrate but to differentiate every

[2] The ability of population 8 to produce galls on *Nicotiana plumbaginifolia* may be somewhat unusual since the writer has learned through personal communication with Dr. E. E. Clayton, Division of Tobacco, Medicinal, and Special Crops, that this plant has been grown in heavily infested soil of several localities in the southeastern states yet appreciable galling has never been observed.

race from every other race is a task that will be neither easy nor quickly accomplished. The designations and origins of the populations used in the following experiments or referred to in the discussion are given in table 1. It should not be assumed that the plant from which a particular race was collected is an especially suitable host for this race or that the plant will be found more commonly infected by this race than by some other. The writer has had under investigation 6 populations from potato (*Solanum tuberosum* L.) each collected in a different locality. These 6 populations included 5 different races. Potatoes become infected with whatever race happens to occur in the region where they are grown and undoubtedly the same is true of many other plants. For example, there is no reason to assume that population 6, by virtue of the fact that it was collected from sweet potato (*Ipomea batatas* (L.) Lam.), occurs more commonly on this crop than population 8. Whether this is or is not the case depends on which population happens to be more widely distributed in the sweet-potato-growing regions.

TABLE 1.—*Sources and designations of the root-knot nematode populations*

Pop. No.	Original host	General locality where collected
1A	Alfalfa	Shafter, Calif.
2	Cotton	Shafter, Calif.
3B	Potato	Harlingen, Tex.
3C	do	Tampa, Fla.
3D	do	Long Island, N. Y.
4	Peanut	Pitt County, N. C.
5	Parsnip	Falls Church, Va.
6	Sweet potato	Beltsville, Md.
8	Tomato	Greenhouse, Beltsville, Md.

Inoculation of plants. Soil and pots used for growing the plants were autoclaved 30 to 40 min. at 15 lb. pressure. Small healthy plants, secured by sowing seed or by some suitable method of vegetative propagation, were set into thumb pots. Each plant was allowed to grow until a loose network of roots had formed over the inner surface of the pot and the plant could be removed with the root system and soil mass intact. With the aid of a pipette the inoculum (a suspension of viable larvae in water) was applied to the sides and bottom of the soil mass and the plant returned to the pot. After 24 hours the plant was again removed and all the soil washed away from the roots. Washing was done carefully to avoid injuring the roots, but thoroughly to remove all larvae that had not already penetrated. The plant was then reset in a larger pot, watered, and shaded from bright sunlight for the first day or two. When the roots of the plant were subsequently examined the age of the parasites, *i.e.*, the length of time they had been in the roots, was known to within the limits of 24 hours.

Examination of plants. Each plant was removed from the pot, the soil washed from the roots, and the entire root system treated with lacto-phenol. The technic was essentially the same as that described by McBeth, Taylor,

and Smith (4) except that Sudan III replaced acid fuchsin as a stain. This treatment clears and softens the roots and stains the parasites, making them easy to see and to remove. A small portion of the root system was clipped off and examined under a low-power, dissecting microscope. So far as possible every parasite contained in this portion of the root system was dissected out and its stage of development determined and recorded. Another portion of the root system was then examined and the operation continued until 100 parasites had been counted and recorded or until the entire root system had been examined. One plant was used for each count.

Data recorded. The parasites were classified into 5 groups based on the amount of development undergone. Group A includes larvae from the

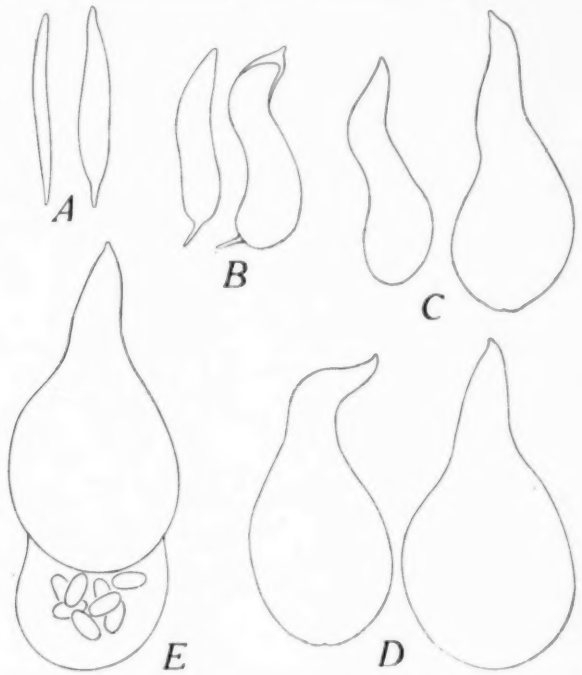

FIG. 1. Groups A through E into which the parasites were classified according to the amount of development undergone.

stage where they have begun to grow to the stage where they still possess a more or less conical tail (Fig. 1, A). Group B includes larvae from the stage where they have acquired a more or less hemispherical posterior end, terminated by a spike, to the stage where they are about to complete the final molts (Fig. 1, B). Group C includes females from the stage where they have completed the molts to the stage where they are almost, though obviously not quite, fully grown (Fig. 1, C). Group D includes females that are fully grown or almost fully grown but have not yet laid eggs (Fig. 1, D). Group E includes egg-laying females (Fig. 1, E).

Because the separation of group A from group B and of group C from

group D depends on artificial cleavages in a graded series, some inconsistencies in placing borderline individuals were unavoidable but the error thus introduced is not sufficient to alter the final picture materially. Sudan III, as used in the technic, does not stain larvae that have undergone no development and if such occurred they are not included in the counts. Adult males were omitted; metamorphosing males were placed in group B.

In the first experiment (Table 2) only 50 parasites from each plant were recorded and no distinction was made between fully-grown females that had, and those that had not, laid eggs. It became obvious, however, that

TABLE 2.—*Comparative development of the root-knot nematode (population 8) in certain varieties of sweet potatoes*

Plant	Period of development		Number of parasites in each group				
	Date infected	Time	A	B	C	D&E	Total
	1942	*weeks*					
Ipomoea batatas (L.) Lam., varieties							
Triumph	Aug. 4–5	3	9	27	12	2	50
		5	6	17	12	15	50
Porto Rico	do	3	10	23	14	3	50
		5	3	6	7	34	50
Nancy Gold	do	3	7	16	17	10	50
		5	0	1	3	46	50
Red Brazil	do	3	0	5	9	36	50
		5	0	0	0	50	50
Jersey Big Stem	Aug. 5–6	3	0	3	16	31	50
		5	0	2	7	41	50
Florida	do	3	3	7	13	27	50
		5	0	0	3	47	50
U.S. No. 47442	do	3	2	9	12	27	50
		5	0	2	7	41	50
Orange Little Stem	Aug. 6–7	3	3	3	0	0	6
		5	0	4	4	0	8
Nancy Hall	do	3	2	9	18	21	50
		5	0	7	3	40	50
Mameyita	Aug. 11–12	3	2	8	33	7	50
		5	0	22	21	7	50

50 was not an adequate number of parasites and that the data would be more informative if egg-laying females were placed in a separate group.

Short time intervals were used in the first experiment lest results be invalidated by the inclusion of second-generation larvae. In subsequent experiments 6-week and, finally, 8-week intervals were included. That second-generation parasites were not encountered is apparent from an examination of the data.

EXPERIMENTAL RESULTS

Results are shown in tables 2 to 7. In the experiment with sweet potatoes (Table 2), parasite development of population 8 was most rapid in Red Brazil though only slightly more so than in Nancy Gold, Jersey Big Stem, Florida, U.S. No. 47442, and Nancy Hall. Development was retarded in

Mameyita and, to a less degree, in Triumph. Orange Little Stem acquired few parasites but the condition of those present suggested that development was somewhat retarded in this variety also.

Reference has already been made to the different rates at which population 8 developed when common tobacco, turnip, *Nicotiana megalosiphon*, and *N. plumbaginifolia*, served as hosts. These differences are clearly indicated by the data in table 3. When development stops, the parasite soon becomes translucent and, eventually, can no longer be recognized, which is probably

TABLE 3.—*Comparative development of the root-knot nematode (populations 1A, 2, 4, and 8) in certain "susceptible" and in certain "resistant" plants*

Plant	Pop. No.	Period of development		Number of parasites in each group					
		Date infected	Time	A	B	C	D	E	Total
		1942–43	*weeks*						
Nicotiana tabacum L. var. Gold Dollar	8	Aug. 18–19	4	0	4	13	63	20	100
	8	Aug. 31–Sept. 1	4	0	4	29	48	19	100
Brassica rapa L. var. Purple-top Strap-leaf	8	Aug. 18–19	4	0	13	65	22	0	100
	8	do	6	0	2	11	26	61	100
Nicotiana megalosiphon Heurck & Muell. Arg.	8	Aug. 24–25	4	13	70	17	0	0	100
	8	do	6	2	59	33	5	1	100
	8	Sept. 2–3	8	1	24	7	3	0	35
Nicotiana plumbaginifolia Viv.	8	Aug. 24–25	4	65	1	0	0	0	66
	8	do	6	0	0	0	0	0	0
Lantana camara L.	8	Aug. 31–Sept. 1	4	0	0	0	0	0	0
Pelargonium graveolens L'Her.	1A	Jan. 9–10	6	3	0	0	0	0	3
	2	do	6	0	0	0	0	0	0
	4	Jan. 1–2	6	0	1	2	14	0	17
	8	do	6	0	0	0	0	0	0
Senecio cineraria DC.	1A	Jan. 18–19	6	15	46	33	6	0	100
	2	do	6	0	3	2	2	2	9
Arachis hypogaea L. var. Virginia Runner	1A	Feb. 1–2	6	15	45	0	0	0	60
	2	do	6	6	16	0	0	0	22
	4	do	6	0	1	3	9	87	100
	6	do	6	0	0	0	0	0	0

the reason why no parasite was found in the 6-week plant of *N. plumbaginifolia* and is possibly the reason why so few were found in the 8-week plant of *N. megalosiphon*. That the same host may affect the development of different races of the parasite in a different manner is shown by the results with peanut (Table 3). (See also results with cotton, *Gossypium hirsutum*, and alfalfa, *Medicago sativa* L., in tables 6 and 7.)

Population 8 developed at about the same rate in each of the varieties of bean (*Phaseolus vulgaris* L.) tested (Table 4) with the probable exception of Alabama No. 1 on which, unfortunately, results are incomplete.

The average rate of development in *Taraxacum kok-saghyz* Rod. was about the same for each of the populations used (Table 5) but with 2, 5,

TABLE 4.—*Comparative development of the root-knot nematode (population 8) in certain varieties of beans*

Plant	Period of development		Number of parasites in each group					
	Date infected	Time	A	B	C	D	E	Total
	1942–43	*weeks*						
Phaseolus vulgaris L., varieties								
Stringless Green Pod	Dec. 28–29	4	4	12	57	27	0	100
	Dec. 31–Jan. 1	6	0	0	0	2	98	100
Caseknife	Dec. 28–29	4	6	20	46	28	0	100
	Dec. 31–Jan. 1	6	0	0	0	2	29	31
Bountiful	Dec. 28–29	4	6	14	76	4	0	100
	Dec. 31–Jan. 1	6	0	2	5	1	92	100
Plentiful	Dec. 28–29	4	4	20	76	0	0	100
	Dec. 31–Jan. 1	6	0	4	5	7	84	100
Pinto (650)	Dec. 28–29	4	4	37	55	4	0	100
	Dec. 31–Jan. 1	6	0	0	0	1	56	57
Davis' White Wax	Dec. 28–29	4	3	43	45	9	0	100
	Dec. 31–Jan. 1	6	0	0	0	8	92	100
Dwarf Horticultural	Dec. 28–29	4	13	45	24	0	0	82
Alabama No. 1	Dec. 28–29	4	2	12	0	0	0	14
Nicotiana tabacum var. Gold Dollar	Dec. 28–29	4	6	28	59	7	0	100
	Dec. 31–Jan. 1	6	0	2	1	3	94	100

and 8 consistently fewer parasites entered the plants than with 1A. This difference was even greater than the table indicates because totals of less than 100 represent all the parasites harbored by a plant while totals of 100 do not. In previous experiments with *T. kok-saghyz* grown from seed,

TABLE 5.—*Comparative development of the root-knot nematode (populations 1A, 2, 5, 8) in Taraxacum kok-saghyz Rod.*

Pop. No.	Period of development		Number of parasites in each group					
	Date infected	Time	A	B	C	D	E	Total
	1942–43	*weeks*						
1A	Nov. 9–10	4	4	19	18	6	0	47
	do	6	9	14	25	34	18	100
	Jan. 18–19	6	11	16	29	20	24	100
	do	6	15	30	21	14	20	100
	do	6	2	13	16	18	51	100
	do	6	5	37	54	2	2	100
	Nov. 9–10	8	4	16	28	1	51	100
2	do	4	0	1	0	0	0	1
	do	6	1	3	2	7	0	13
	Jan. 18–19	6	3	9	15	13	16	56
	do	6	1	4	14	24	40	83
	do	6	6	9	5	16	40	76
	Nov. 9–10	8	4	8	13	0	12	37
5	Jan. 22–23	6	0	6	0	0	44	50
	Nov. 9–10	4	9	6	4	0	0	19
	do	6	0	18	14	12	8	52
	do	8	0	0	1	0	7	8

results suggested the possibility that individual plants differed in their relations to the parasite. In view of these previous results it is interesting to note the conspicuous developmental lag that occurred in one of the plants infected with population 1A (Table 5).

Larvae of population 1A entered the roots of cotton freely but development was sharply retarded and was not much more advanced at the end of 8 weeks than at the end of 4 weeks (Table 6). The development of population 2 was moderately rapid. The development of population 1A in alfalfa (Table 7) was about the same as the development of population 2 in cotton

TABLE 6.—*Comparative development of the root-knot nematode (populations 1A and 2) in cotton (variety Coker 100)*

Pop. No.	Period of development		Number of parasites in each group					
	Date infected	Time	A	B	C	D	E	Total
	1942–43	*weeks*						
1A	Nov. 16–17	4	48	52	0	0	0	100
	Nov. 19–20	4	85	15	0	0	0	100
	Jan. 15–16	4	63	10	0	0	0	73
	do	4	83	17	0	0	0	100
	Nov. 16–17	6	46	52	2	0	0	100
	Nov. 19–20	6	18	21	3	0	0	42
	Nov. 23–24	6	59	41	0	0	0	100
	Jan. 15–16	6	75	25	0	0	0	100
	Jan. 15–16	8	56	44	0	0	0	100
	Jan. 20–21	8	32	67	1	0	0	100
	do	8	22	77	1	0	0	100
2	Nov. 16–17	4	5	30	34	31	0	100
	Nov. 19–20	4	15	71	13	1	0	100
	Jan. 15–16	4	13	64	23	0	0	100
	do	4	16	58	16	10	0	100
	Nov. 16–17	6	4	25	31	28	12	100
	Nov. 19–20	6	0	18	33	30	19	100
	Nov. 23–24	6	2	15	26	34	6	83
	Jan. 15–16	6	5	23	32	31	9	100
	do	8	0	3	10	20	67	100
	Jan. 20–21	8	0	5	11	14	70	100
	do	8	0	2	13	22	63	100
	do	8	0	3	21	26	50	100

but 2 failed to infect alfalfa to any appreciable extent. This failure is not surprising since larvae of other populations have failed to enter the roots of certain plants, or have entered in very small numbers, but the development of the few parasites of population 2 found in alfalfa does not appear to have been appreciably retarded. Differences in the number of parasites harbored by the different plants in this and other experiments were due, in some measure, to differences in the number of larvae to which they were exposed. Furthermore, the root system of alfalfa seedlings is less branched and has fewer root tips than that of many plants, and the roots grow downward and coil in the bottom of the pot. It was difficult to infect alfalfa with an adequate number of parasites regardless of the population employed. However, neither the character of the root system nor the number of larvae to which it was exposed can account for the almost complete failure to infect

alfalfa with population 2. That this population included more than one race is, admittedly, a possibility.

SUPPLEMENTARY OBSERVATIONS AND DISCUSSION

Many plants are regarded as "resistant," not because larvae fail to enter but because they fail to develop after entering. Barrons (1) found no significant difference between the mean number of larvae per rootlet in such "resistant" plants as corn (*Zea mays* L.), oats, rye, onion, crotalaria (*Crotalaria spectabilis*), and bean (var. Alabama No. 1) and such "susceptible" plants as cowpea (var. Cream Crowder), okra, bean (var. Kentucky

TABLE 7.—*Comparative development of the root-knot nematode (populations 1A and 2) in alfalfa*

Pop. No.	Period of development		Number of parasites in each group					
	Date infected	Time	A	B	C	D	E	Total
	1942–43	*weeks*						
1A	Oct. 26–27	4	4	32	13	0	0	49
	Oct. 29–30	6	1	25	29	42	3	100
	Jan. 4–5	6	0	2	3	19	9	33
	Jan. 25–26	6	0	3	8	7	22	40
	do	6	1	7	19	13	38	78
	do	6	0	3	6	25	66	100
	Nov. 2–3	8	0	4	15	16	65	100
	Jan. 1–2	8	0	1	7	5	26	39
	do	8	0	0	3	27	70	100
	Jan. 4–5	8	0	0	1	0	56	57
	do	8	0	0	2	7	81	90
2	Oct. 29–30	6	0	0	0	0	0	0
	Jan. 4–5	6	0	0	0	0	0	0
	Jan. 25–26	6	0	1	1	5	2	9
	do	6	0	0	1	1	0	2
	do	6	0	0	1	1	0	2
	Nov. 2–3	8	0	0	0	0	0	0
	Jan. 2–3	8	0	0	0	0	1	1
	do	8	0	0	0	0	0	0
	Jan. 4–5	8	0	1	0	0	0	1
	do	8	0	0	0	0	0	0

Wonder), and tomato, when all were equally exposed to infection. Results from the present experiments indicate, nevertheless, that larvae do not enter the roots of some plants as readily or in as large numbers as they do others and the existence of plants immune to invasion, at least by some races, seems a likely possibility.

The inoculum potential of the soil may be influenced, no doubt, by many factors but it is directly dependent, initially, on the egg production of the parasites. Conspicuous galling on the roots of a crop may not be an infallible indication that a following crop of the same kind will be equally affected. Subsequent generations of the parasite develop from eggs, not from galls. A plant may have galling of considerable severity yet development of the parasites may be sufficiently retarded to result in a pronounced reduction or, in some cases, an almost complete suppression of egg-laying

and this will be reflected, eventually, by a corresponding decline in soil infestation. It is erroneous to assume that such a decline cannot occur if the crop is one of those that have come to be regarded as highly "susceptible." No plant is an equally suitable host for all races.

The influence of some of these effects of the host on the parasite became manifest, unexpectedly, when attempts were made to build up and maintain different populations for experimental purposes. When tomato (*Lycopersicum esculentum* Mill.) was used as a maintenance plant the initial suc-

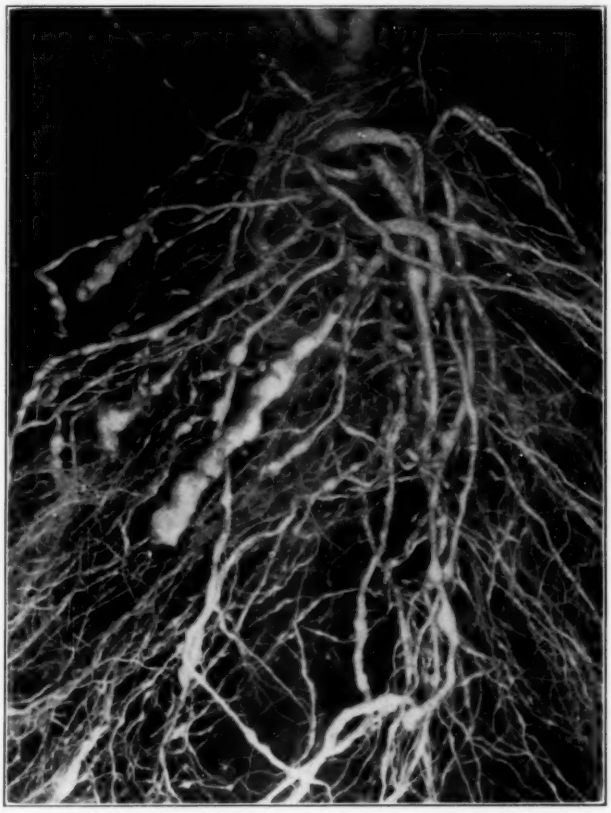

FIG. 2. Root system of a plant of *Nicotiana plumbaginifolia* that had been growing for 61 days in soil infested with the root-knot nematode, population 8.

cess, with a few exceptions, seemed fairly satisfactory but eventually it became evident that all populations were not being maintained at a high level. For example, when potato tubers infected with population 3D were used as inoculum, a very severe infection could be produced on tomato. When the roots of a tomato plant thus infected were used as inoculum to infect another tomato plant the resulting infection was less severe. With repeated transfers from tomato to tomato the severity of the infection declined until it became moderate to light. Somewhat similar results were obtained when attempts were made to segregate and build up populations from single egg masses, of which the following is an interesting example.

Eight small plants of common tobacco were inoculated by placing among the roots of each a single egg mass of population 3B, and 8 similar plants were inoculated in the same manner with population 3C. These two populations were known to produce severe galling on tobacco and previous work had given no intimation that tobacco was not equally suitable for, and equally affected by, both. All the plants came from the same lot

FIG. 3. Root systems of tobacco plants infected with the root-knot nematode. When these plants were small a single nematode egg mass was placed among the roots of each, the upper row being infected in this manner with population 3B and the lower row with population 3C. Photographed 15 weeks later.

of seedlings, were approximately the same size, were inoculated at the same time, were potted in the same sized pots using the same kind of soil, and were grown on the same greenhouse bench. All plants within each group grew at about the same rate, maintaining approximately the same size but, by the end of 4 or 5 weeks there was a very noticeable difference between the groups, those inoculated with population 3B being larger. This dif-

ference was maintained throughout the growth of the plants, eventually becoming very conspicuous. After 15 weeks all plants were removed from the pots and the roots washed free of soil. The degree of galling within each group was remarkably uniform but the plants harboring population 3C were much more heavily infected and much more severely galled than those harboring population 3B. The photographs reproduced in figure 3 show fairly well the pronounced difference between the groups with respect to galling but they do not show the even more pronounced difference with respect to egg production. Egg masses were present on the roots of the plants infected with population 3B but there were comparatively few, while on the plants infected with population 3C they were exceedingly abundant. When these plants were inoculated the egg masses used had been selected as being large and of uniform size but the number of eggs per egg mass was not determined. It was conceivable, therefore, that the egg masses selected from population 3C contained a larger number of eggs than did those selected from 3B. To secure some indication regarding the likelihood that this was the case, counts were made subsequently on egg masses similar to those used to inoculate the plants. In round numbers, eggs per egg mass varied from about 300 to 500 with no apparent difference between populations.

CONCLUSIONS

Some plants are highly suitable hosts for a given race of the root-knot nematode and others are highly unsuitable hosts, but most lie between these two extremes and nearly every degree of suitability may be encountered. Retarded development of the parasite is a manifestation of unsuitability or (if we define resistance in a plant as its condition of being an unsuitable host) of resistance. There appears to be no correlation between the suitability of the host and the freedom with which larvae enter its roots. Many plants that are highly unsuitable are invaded as freely as more suitable ones. The present experiments indicate that, even though given an ample opportunity, larvae enter some plants in very small numbers although it remains to be demonstrated that any one of the flowering plants is immune from invasion. Results with alfalfa raise some doubts that failure of larvae to enter a plant in large numbers can be accepted as *prima facie* evidence of unsuitability. There appears to be a direct correlation between suitability of the host and rate of parasite development and a direct correlation between rate of parasite development and egg production. Where parasite development is only slightly retarded the effect may be little more than to reduce the number of generations that occur in a given period. When development is more strongly retarded many of the females may never reach maturity and there may be a reduction in the egg output of those that do. In extreme cases development is almost completely suppressed and, of course, eggs are not produced. Unsuitability of the host

with its various consequences is not necessarily accompanied by a corresponding reduction in severity of galling.

PLANT INDUSTRY STATION,
BELTSVILLE, MARYLAND

LITERATURE CITED

1. BARRONS, KEITH C. Studies of the nature of root knot resistance. Jour. Agr. Res. [U.S.] **58**: 263–271. 1939.
2. CHRISTIE, JESSE R., and FLORENCE E. ALBIN. Host-parasite relationships of the root-knot nematode, Heterodera marioni. I. The question of races. Proc. Helminth. Soc. Washington **11**: 31–37. 1944.
3. GODFREY, G. H., and JULIETTE OLIVEIRA. The development of the root-knot nematode in relation to root tissues of pineapple and cowpea. Phytopath. **22**: 325–348. 1932.
4. MCBETH, C. W., A. L. TAYLOR, and A. L. SMITH. Notes on staining nematodes in root tissues. Proc. Helminth. Soc. Washington **8**: 26. 1941.
5. TYLER, JOCELYN. Development of the root-knot nematode as affected by temperature. Hilgardia **7**: 392–415. 1933.

TEMPERATURE EFFECTS ON THE EXPRESSION OF THE YELLOWS VIRUS IN SOUR CHERRIES

W. D. Mills

(Accepted for publication January 30, 1946)

The virus yellows of sour cherries has long been present in New York State orchards. Stewart (9) accurately described the symptoms. He stated that the trouble occurred occasionally in sour cherries and ascribed it to "unfavorable soil and weather conditions." The disease has been reported in The Weekly News Letter[1] as occurring in varying amounts since 1921. Crosby, Mills, and Blauvelt (1) described the disease as a physiological leaf drop "apparently correlated with winter injury" in their bulletin and in subsequent annual revisions until Keitt and Clayton (6, 7) demonstrated that a bud-transmissible virus was responsible, after which it was referred to (2) as virus leaf drop. Hildebrand and Mills (5) reported that the yellowing and dropping of leaves caused by the virus yellows was prevalent in New York during 1928, 1931, 1935, 1937, and 1938. This report was based on the plant disease records of the writer for the years 1928 to 1940.

Subsequent studies have been made of The Weekly News Letter and the fruit disease questionnaires, which have been filled out annually in the commercial fruit-growing counties since 1931. These records indicate that in 8 of the last 25 years the symptoms of yellows have been unusually severe. These years were 1921, 1927, 1928, 1931, 1938, 1941, 1942, and 1945. Distinctly less yellows occurred in 1935 and 1937 and these two years were placed in the moderate group after careful study of the available records.

Hildebrand (4) stated that virus yellows symptoms were obscured by defoliation from fungus leaf spot in 1943. It seems evident that some other factor than the incidence of cherry leaf spot (*Coccomyces hiemalis*) must be sought to explain the variation in the amount of the yellows symptoms during the last 25 years in this State. During the 8 separate years when yellows symptoms were unusually severe, leaf spot was severe in 3 years, slight to moderate in 2 years, and very slight to a trace in 3 years. In the 16 years when the yellows symptoms were less intense, the leaf spot was severe in 4 years, slight to moderate in 7, and very slight to a trace in 5 years.

A possible explanation for the wide variation in the expression of the yellows virus from year to year in the orchard appears in the greenhouse experiments of Keitt and Moore (8) who found that there is a masking of the yellows symptoms when trees which have been budded with infected buds are held at high temperatures. Yellows symptoms were freely expressed in the budded trees held at 16° C. (60.8° F.), only one budded tree showed the symptoms when held at 20° C. (68° F.), and no trees budded

[1] The Weekly News Letter is a mimeographed compilation of weekly reports on disease and insect development in New York State, issued since 1919.

and held at 24° C. or 28° C. developed the yellows symptoms. These data indicate that partial or complete masking of the symptoms occurs when the temperature rises much above 61° F.

The records mentioned above were tabulated for Montmorency cherry orchards near Lake Ontario to show, for each of the last 25 years, the date of the beginning of bloom, of the petal-fall stage, and of the first appearance of the yellows symptoms. From the climatological data of the Rochester office of the United States Weather Bureau, the mean temperatures were determined for 10-day periods in relation to the petal-fall stage for each year. Figures for the 8 years when the yellows symptoms were most severe were placed in one group, and figures for the 17 remaining years were in a second group. The two groups were then treated statistically to determine whether any significant difference existed for any of the 10-day periods between the years when yellows symptoms were strongest and the years when the symptoms were less pronounced. In table 1 the mean temperatures for the various periods are given for the 8 years of conspicuous yellows symptoms and for the 17 years of lighter symptoms. The F values and the odds are included to show the relative significance of the differences in mean temperatures. It will be noted (Table 1) that the mean temperature for each period was always lower for the years when heavy yellows symptoms occurred than for the years of lighter yellows expression. The first, second, and third 10-day periods following the petal-fall stage show a very significantly lower temperature for the years of severe yellows. The 10-day period preceding the petal-fall stage and the period 31 to 40 days after the petal-fall show only a probable significant decrease in mean temperature for the years of severe yellows. Various 20- and 30-day periods in relation to the petal fall are included in table 1. All but one of these periods show a very significantly lower mean temperature for the years when the yellows was most severe. As might be expected from the differences shown by the 10-day periods, the 30-day period following the petal fall shows the most significant differences in temperature as indicated by the highest F value of 33.01.

Before the temperature records were compiled, it was noted that the years of earliest cherry bloom were also the years in which the most severe yellows appeared. The average number of days after April 10 for the beginning of bloom was 18.12 for the 8 years of heavy yellows and 32.41 for the 17 years of lighter yellows with a highly significant F value for the difference of 20.85. In other words, the average calendar date for the beginning of bloom in the 8 years of heavy yellows was April 28, which was very significantly earlier than May 12, the average date for the years of lighter yellows symptoms. The average date of the petal-fall stage was May 12 for the years of heavy yellows, very significantly earlier than the average date of May 25 for the years of lighter symptoms, as shown by an F value of 17.51. Sour cherries began to bloom in the Lake Ontario cherry belt on April 16 in 1945 and the writer ventured to predict at that time that,

with one of the earliest bloom periods on record, we should expect heavier yellows in 1945 than in the two previous years, since in 1943 the bloom was later than average and in 1944 only a few days earlier than average. This 1945 season proved to be the year with the most severe yellows on record. The reason for this is obvious. Leaf development in sour cherries starts at about the petal-fall stage and is rapid during the next few weeks. An early bloom period, as in 1945, is followed by this leaf development in May when the normal monthly mean temperature is about 56° F. instead of occurring largely in June when the normal monthly mean is about 66° F. in this area.

The relation betweeen the date of bloom and the average temperature for the 30 days after petal fall was measured by computing the correlation

TABLE 1.—*Mean temperatures of various periods in relation to the petal-fall stage in 8 years of heavy yellows symptoms and in 17 years of lighter symptoms for the 25 years of 1921 to 1945*

Ten-day period	Mean temperature, degrees F.		F	Odds
	8 years, heavy yellows	17 years, light yellows		
0– 9 days before petal fall	54.99	59.29	5.74	19 to 1
1–10 days after petal fall	55.35	62.85	11.01	99 to 1
11–20 do	58.89	65.62	14.32	99 to 1
21–30 do	63.84	68.62	13.78	99 to 1
31–40 do	64.65	69.49	5.98	19 to 1
10 before to 10 after	55.19	61.08	7.74	19 to 1
1–20 days after petal fall	57.12	64.25	20.78	99 to 1
1–30 do	59.32	65.68	33.01	99 to 1

between the number of days after April 10 when the bloom began with the mean temperature of this 30-day period after the petal-fall stage. For the 25 years the coefficient of correlation was +0.789, giving odds of 99 to 1 that the temperatures are correlated with the bloom date. The regression was +0.31, so that for each day later the bloom began the average temperature of the 30-day period rose three-tenths of a degree Fahrenheit. The correlation of the date of the petal-fall stage and average temperature for the following 30 days also was computed. The correlation coefficient was highly significant (+0.732) and the regression value of +0.30 again showed a rise of three-tenths of a degree for the 30 days after petal fall for each day the petal-fall stage was delayed.

While high temperatures in the 30 days following the petal-fall stage decrease the yellows symptoms, higher than normal temperatures in March and April tend to increase the yellows symptoms which appear later in the orchard. This apparent contradiction is due to the fact that high temperatures early in the season cause an earlier bloom and this earlier bloom is followed in most years by lower temperatures after the petal-fall stage and

a consequent greater manifestation of yellows symptoms. This is shown by a highly significant correlation of the mean temperature for March and April with the date of the petal-fall stage. The correlation coefficient for the 25 years is -0.7684 and the regression value -2.01 days. For each increase of 1 degree in the mean temperature the petal fall occurs 2 days earlier. The monthly mean temperatures for March, April, May, and June for the years of heavy and light yellows are in table 2. The increase in the mean temperature for March in the years of heavy yellows is not quite enough for odds of 19 to 1. The F value is 4.26 when 4.28 is required for these odds. The increase in the mean temperature for April in the years of heavy yellows is highly significant as shown by the F value of 15.74, well over the value required for odds of 99 to 1. No significant differences occur in the mean temperatures for May and June between the years of heavy yellows and those of light symptoms.

TABLE 2.—*Mean monthly temperatures for the 8 years of heavy yellows and the 17 years of lighter symptoms*

Month	Mean temperature, degrees F.		F	Odds[a]
	8 years, heavy yellows	17 years, light yellows		
March	36.7	33.6	4.26	n.s.
April	48.2	43.5	15.74	99 to 1
May	57.2	56.9	.....	n.s.
June	66.4	67.3	.....	n.s.

[a] n.s. indicates no significance.

The possible additional effects of the prevailing temperatures during the time the yellows symptoms appear, on the severity of the expression of symptoms was investigated. The mean temperatures of 10-day periods in relation to the date of first appearance of the yellows were computed for the 8 years of most severe yellows and for 14 years when the yellows symptoms were less prominent. In three years of light yellows the date of first appearance was not recorded. These mean temperatures, in relation to the time of appearance of yellows symptoms, are given in table 3.

The only period in which the temperatures show a probable significant difference is the 10-day period just preceding the appearance of yellows. This period is approximately the same as the 21–30-day period after petal fall (Table 1).

The 10-, 20-, or 30-day periods after yellows symptoms first appear show no significant differences in temperatures for years of heavy and light yellows. These data indicate that the prevailing temperatures during the time of appearance of yellows symptoms do not appreciably affect the magnitude of these symptoms.

TABLE 3.—*Mean temperatures of various periods in relation to the first appearance of yellows symptoms for 8 years of severe and for 14 years of light yellows*

Ten-day period	Mean temperature, degrees F.		F	Odds[a]
	8 years, heavy yellows	14 years, light yellows		
0– 9 days before 1st yellows	63.90	69.38	7.2	19 to 1
1–10 days after 1st yellows	68.42	70.46	2.8	n.s.
11–20 do	72.81	72.20	< 1.0	do
21–30 do	72.62	72.70	< 1.0	do
1–20 do	70.64	71.31	< 1.0	do
1–30 do	71.31	71.78	< 1.0	do

[a] n.s. indicates no significance.

The possibility that the amount of precipitation might influence the appearance of yellows symptoms also was investigated. The total precipitation for January, February, March, and April did not differ significantly for the years of heavy and of light yellows as shown by an F value of only 1.2. The total precipitation was computed for all the periods used in the temperature studies in relation to the petal-fall stage (Table 1), and to the time of appearance of symptoms (Table 3). No consistent increases or decreases in precipitation occurred in the years of heavy yellows as compared with the years of light or moderate yellows, and in no period did the difference in precipitation approach even probable significance. It appears that no measurable effect on the expression of yellows in the 25 years was the result of variations in precipitation.

CONCLUSIONS

The chief factor determining the expression of virus yellows in the orchard in any given season is the prevailing temperature during the 30-day period following the petal-fall stage. The effect of early bloom in increasing the expression of yellows symptoms is due to the lower temperatures normally following such an early bloom. The prevailing temperatures after yellows symptoms first appear do not affect the degree of these symptoms. The amount of precipitation in any season does not appear to affect the severity of yellows symptoms. The incidence of cherry leaf spot also does not appear to influence the appearance of yellows symptoms.

Since prevailing temperatures following the petal-fall stage cause a great variation in the apparent amount of virus yellows present in an orchard from year to year, it appears that no data observed to date, based on the apparent incidence of yellows in two different years, prove or disprove spread of the cherry-yellows virus after the trees are set in the orchard.

DEPARTMENT OF PLANT PATHOLOGY,
CORNELL UNIVERSITY.

LITERATURE CITED

1. CROSBY, C. R., W. D. MILLS, and W. E. BLAUVELT. Protecting orchard crops from diseases and insects. N. Y. (Cornell) Agr. Exp. Stat. Bull. 498. 1929.
2. ———, ———, ———, and J. A. EVANS. Protecting orchard crops from diseases and insects in western New York. N. Y. (Cornell) Agr. Exp. Stat. Ext. Bull. 313. 1935 (Revised 1940).
3. ———, ———, and J. A. EVANS. Protecting orchard crops from diseases and insects in eastern New York. N. Y. (Cornell) Agr. Exp. Stat. Ext. Bull. 314. 1935 (Revised 1940).
4. HILDEBRAND, E. M. Virus symptoms on Montmorency cherry in a bad fungous leaf spot year. U. S. Dept. Agr., Plant Dis. Reptr. **28**: 993–994. 1944.
5. ———, and W. D. MILLS. Cherry yellows (physiological yellow leaf) in New York. Phytopath. **31**: 355–356. 1941.
6. KEITT, G. W., and C. N. CLAYTON. A destructive bud-transmissible disease of sour cherry in Wisconsin. Phytopath. **29**: 821–822. 1939.
7. ———, and ———. A destructive bud transmissible disease of sour cherry. Wisconsin Hort. **30**: 376. 1940.
8. ———, and J. D. MOORE. Masking of leaf symptoms of sour cherry yellows by temperature effects. Phytopath. **33**: 1213–1215. 1943.
9. STEWART, F. C. Notes on New York plant diseases. II. N. Y. (Geneva) Agr. Exp. Stat. Bull. 463: 157–188. 1919.

MOSAICS OF WINTER OATS INDUCED BY SOIL-BORNE VIRUSES

H. H. McKinney[1]

(Accepted for publication January 30, 1946)

INTRODUCTION

In 1943, the writer received diseased winter-grown Quincy Red oat plants that had been sent to the Department by J. L. Seal, Pathologist at the Alabama Agricultural Experiment Station. These plants were approaching maturity and were dead when received, but the leaf symptoms were suggestive of mosaic. Another lot of diseased plants was submitted by Dr. Seal and inoculations were made into oats, wheat, and corn. The results were negative. In the late spring of 1944, Seal submitted diseased plants again. These were transplanted, but they were not thrifty. The symptoms were unmistakably typical mosaic. However, attempts to effect a transmission failed. In the spring of 1944 R. E. Atkinson of the Emergency Plant Disease Survey, of the Bureau of Plant Industry, Soils, and Agricultural Engineering, sent winter oat plants to Beltsville, Md., from South Carolina and later the writer collected mosaic plants from points in North Carolina and South Carolina. All of these collections were potted and cultured in a greenhouse. Although the symptoms were characteristic of mosaic, all attempts to transmit a virus again met with failure.

On a basis of these failures, it was concluded that the viruses of Brome mosaic (*Marmor graminis* McK.)[2] and of the wheat streak mosaics (*M. virgatum* McK.),[2] which infect oats, corn, and wheat at summer temperatures, probably were not the causes. Adequate facilities for obtaining low-temperature culture conditions were not available for testing inoculations at temperatures near 60° and 65° F., the optimum range for the soil-borne viruses infecting wheat.

DISTRIBUTION, RECURRENCE, AND IMPORTANCE

Oat mosaic has appeared in four successive seasons on the same land in a limited area at Auburn, Ala., and in two successive years on the same land at Hartsville and Clemson, S. C., and Statesville, N. C.

[1] Senior Pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture.

The author is indebted to Matthew Koerner for assisting in conducting the tests; to J. L. Seal and T. H. Rogers of the Alabama Agricultural Experiment Station; R. P. Bledsoe of the Georgia Agricultural Experiment Station; G. H. Armstrong and W. R. Paden of the South Carolina Agricultural Experiment Station; G. K. Middleton of the North Carolina Agricultural Experiment Station; J. W. Hendricks of the North Carolina Department of Agriculture and to Coker's Pedigreed Seed Co., Hartsville, South Carolina, for supplying seed, infested soil, plant materials, and other facilities. Most of the seed used in the tests was provided by T. R. Stanton, Senior Agronomist in charge of oat investigations, of this Division.

[2] McKinney, H. H. Descriptions and revisions of several species of viruses in the genera Marmor, Fractilinea, and Galla. Jour. Washington Acad. Sci. **34**: 322–329. 1944.

During the season of 1944, R. E. Atkinson made a survey in many fields of oats in the Carolinas, and in his report,[3] he indicates the presence of oat mosaic in 9 counties in North Carolina and in 10 counties in South Carolina.

During the season of 1945, the writer examined many oat fields in South Carolina, and found mosaic in Pickens and Darlington Counties. During the same season, A. E. Prince of the Emergency Plant Disease Survey made a survey of oat fields in the Carolinas and found oat mosaic in Oconee, Pickens, and Darlington Counties in South Carolina and in Iredell County, North Carolina.

The disease was more severe in 1944 than in 1945. Susceptible varieties such as Letoria (C.I. 3392), Bond (C.I. 2733), Camellia (C.I. 4079), and Victoria (C.I. 2401) were greatly retarded and severely damaged in 1944, whereas in 1945 these varieties showed much less damage, even though infected.

As in the wheat mosaics, seasonal conditions, especially temperature, appear to influence the amount of damage caused by oat mosaic. Under suitable conditions the disease is capable of causing severe damage to certain varieties. It appears that control can be effected through resistant lines and varieties.

SPREAD OF OAT MOSAIC

By soil

Soils in which mosaic oats had grown were collected at Auburn, Ala., and Statesville, N. C., transported to Beltsville, Md., and placed in separate wooden bins, located out of doors. The bins were 48 inches long, 12 inches wide, and 12 inches deep. Similar bins placed nearby were filled with non-mosaic soil from Beltsville to serve as controls.

On October 6, 1944, seed of Letoria (C.I. 3392), Iowa Winter Sel. 8 (C.I. 4467), and Victoria × Rainbow (C.I. 4191) oats were sown in the bins.

On November 25, 40 days after seeding, samples of plants were removed from the bins. These seedlings and roots were thoroughly washed and disinfected in a solution of 1 part mercuric chloride in 999 parts of water. After this treatment, the seedlings were transplanted to steamed, fertile potting soil and then grown in a greenhouse controlled for 65° F.

On December 1, four of the plants removed from the soils obtained at Auburn, Ala., and Statesville, N. C., showed mosaic. No mosaic appeared in plants removed from the Beltsville soil (Fig. 1).

On December 9, the bins of infested and noninfested soils with the remaining plants, were brought into the greenhouse (65° F.). A few of the plants had a faint mottling at this time, and within 10 days mosaic was very evident in all of the plants in the Auburn and Statesville soils, whereas all plants growing in Beltsville soil remained perfectly healthy. Subsequent tests indicate that 60° is more favorable than 65° F. for inducing mosaic from the soil, but 65° has been more favorable for the full expression

[3] Atkinson, R. E. A new mosaic chlorosis of oats in the Carolinas. U. S. Dept. Agr., Plant Dis. Reptr. **29**: 86–89. 1945.

of symptoms. The results of these tests demonstrate that the oat-mosaic-inducing agent is associated in some way with the soil, and that the agent overseasons in the soil.

Wheats known to be highly susceptible to the soil-borne wheat mosaic viruses, *Marmor tritici* H. emend McK.,[4] failed to develop mosaic when sown

FIG. 1. Oat plants of the hybrid Victoria × Rainbow. All plants grown concurrently out of doors for 40 days during the autumn, and in a greenhouse during the winter at Beltsville, Md. Photographed 76 days after seeding, 36 days after transplanting. Left: healthy plants cultured in field soil that does not induce mosaic. Right: diseased plants cultured in field soil in which mosaic oat plants had grown the previous crop season, then transplanted to steamed greenhouse soil. These plants had mosaic mottling.

At time of transplanting, the underground parts of both lots of plants were washed thoroughly, placed in a 1:1000 solution of mercuric chloride in water for 10 minutes, and transplanted without rinsing in water.

in soil carrying the oat-mosaic agents at Statesville, N. C., Clemson, S. C., Hartsville, S. C., and Auburn, Ala., while adjacent rows of oats developed high percentages of mosaic. Varieties of winter oats now known to be susceptible to the oat mosaics under discussion have failed to develop mosaic when sown in soil carrying wheat-mosaic viruses at Arlington Experimental Farm, Va., and near Marshall, Ill. Winter oats have been tested in soils

[4] See footnote 2.

infested with wheat-mosaic viruses at several other points farther north in Illinois and at Lafayette, Indiana, but winter survival was always low or nil. Mosaic has never been observed in any surviving oat plants in these tests.[5]

FIG. 2. Letoria oat plants illustrating nontransmission of mosaic through seed from mosaic plants. Left: typical plant from seed of mosaic plants cultured in non-mosaic-inducing soil. Center: typical plant from seed from mosaic-free plants. Right: typical diseased plant, stunted by mosaic, from seed of mosaic-free plants cultured in field soil in which mosaic oat plants had grown the previous crop season.

Tests with Seed from Diseased Plants

Seed of the varieties, Letoria (C.I. 3392), Victoria × Rainbow (C.I. 4191), and Iowa Winter Sel. 8 (C.I. 4467) was collected from field-grown plants

[5] Cooperative tests with Benj. Koehler and Ralph M. Caldwell of the Illinois and the Purdue Agricultural Experiment Stations, respectively.

having severe mosaic symptoms. In the autumn of 1944 these lots were sown outdoors in bins of nonmosaic soil at Beltsville, Md. Each lot of seed was sown at the rate of 1 gram per foot in 1 row 48 inches long. The stands were excellent and remained so during the test. On December 9 these bins were removed to a greenhouse controlled near 65° F. The plants were thrifty and remained completely free of mosaic throughout their life (Fig. 2). Throughout the test, these plants were near the mosaic plants growing in the infested soils.

INOCULATION TESTS

In August, 1944, soil from an oat-mosaic infested plot at Auburn, Ala., was planted to Letoria oats at Beltsville, Maryland. Culture was in 6-inch earthen greenhouse pots in a chamber controlled near 60° F. On October 19, the pots and plants were transferred to a greenhouse in which the temperature was 65° F. during the night and overcast days. On November 6, mosaic was evident in most of the plants. On November 14, 74 healthy young seedlings of Letoria oats in 2–3-leaf stage were inoculated with an extract made from finely pulped leaf and sheath tissue from the mosaic plants. The tissue was pulped with quartz sand in a mortar, with sufficient water to make inoculum the consistency of a thick porridge. Carborundum powder (600-grain) was added to the inoculum. Thumb and forefinger were dipped in this mixture and used to wipe the leaves of the seedlings, and the residue was rinsed off with water.

After inoculation the plants were cultured at 60–65° F. The first signs of mosaic appeared 13 days after inoculation. Of the 74 seedlings inoculated, 17, or nearly 23 per cent, developed mosaic.

A total of 3,273 oat plants have been inoculated with extracts from mosaic oat plants, and 972 plants (29.7 per cent) became infected. Single sources have been subtransferred successfully to oats as many as 3 times.

The early failures to transmit oat mosaics are attributed largely to the fact that suitable temperatures were not available for the culture of the seedlings before and after inoculation. When cultured at temperatures much above 60° F., the leaves of oat seedlings are very tender and subject to severe injury from the inoculation technic. Such injuries tend to interfere with increase and movement of the virus.

Of 40 inoculation tests made since the first successful inoculation, 3 tests have failed completely, and only one has given 100 per cent infection, with 11 plants in that test. Thus far, these oat-mosaic viruses have been much more difficult to transmit manually than the soil-borne wheat-mosaic viruses.

GENERAL SYMPTOMS IN PLANTS INFECTED FROM SOIL

The first signs of oat mosaic in the field appear as soon as the plants start growth in the spring. In 1945, at Auburn, Ala., the first signs were evident the second week in January, and at Statesville, N. C., they were just appearing the first week in March.

The leaves manifest chlorotic streaks, spots, and patches. Depending on the variety of oats and the seasonal conditions, the chlorosis ranges from a very faint light green to yellow or ashen gray. The patterns and their persistence vary somewhat with the oat variety, the seasonal conditions, and the predominating type of virus. In 1944, the chlorosis was generally more severe and more persistent; also there was more stunting of plants than was the case in 1945.

In Letoria and Victoria × Rainbow, the two varieties studied thus far, the symptoms were most severe at 60 to 65° F., 65° being slightly more favorable for chlorosis than 60°. As the temperatures reached 70° F. and above, the new leaves had weak symptoms or none at all. However, assays on such plants revealed virus in flag leaves that had no visible signs of mosaic.

Mosaic plants growing in pots in the greenhouse and out of doors during the spring showed marked fluctuations in the expression of mosaic in growing leaves with changes in temperature. During cool periods the symptoms were much more evident than during warm periods.

In the field, several varieties of oats such as Appler (C.I. 1815) manifest extremely mild, light-green mottling and sometimes none. A few hybrids, Palestine × Dawn (C.I. 4230) and two sister hybrids Lee × (Bond–Iogold) C.I. 4212 and C.I. 4214, developed rosette symptoms in portions of the populations.

SYMPTOMS INDUCED BY TWO ISOLATES FROM DISEASED PLANTS

Owing to the difficulty of effecting manual transmission, symptom reactions are the only properties of the virus isolates that have been studied.

Apical-mosaic Virus

The isolate here described originated from an oat plant growing in virus-infested soil collected on the Piedmont Branch Experiment Station, Statesville, North Carolina.

In Letoria and Victoria × Rainbow oats, the symptoms range from light green to yellow narrow lines to typical grass-mosaic type of mottling and blotching. The chlorotic patterns tend to be confined to the top 1 to 3 leaves of the plants, and the patterns tend to be massed towards the distal portion of the leaf as illustrated in figure 3. The emerging leaf commonly has the strongest chlorosis, and usually this is in the form of short broken lines. At 65° F., the severity of the chlorosis gradually reduces with the development of the leaf, and may disappear completely, tending to disappear last from the distal region of the leaf. However, sometimes tips of these leaves have become completely chlorotic prematurely when the plants were transferred to 80° F. When high temperatures continued, the new foliage failed to show signs of the disease. Upper leaf sheaths sometimes manifest mottling for a few days at cool temperatures.

Apical mosaic seems to be the predominating oat mosaic in all of the

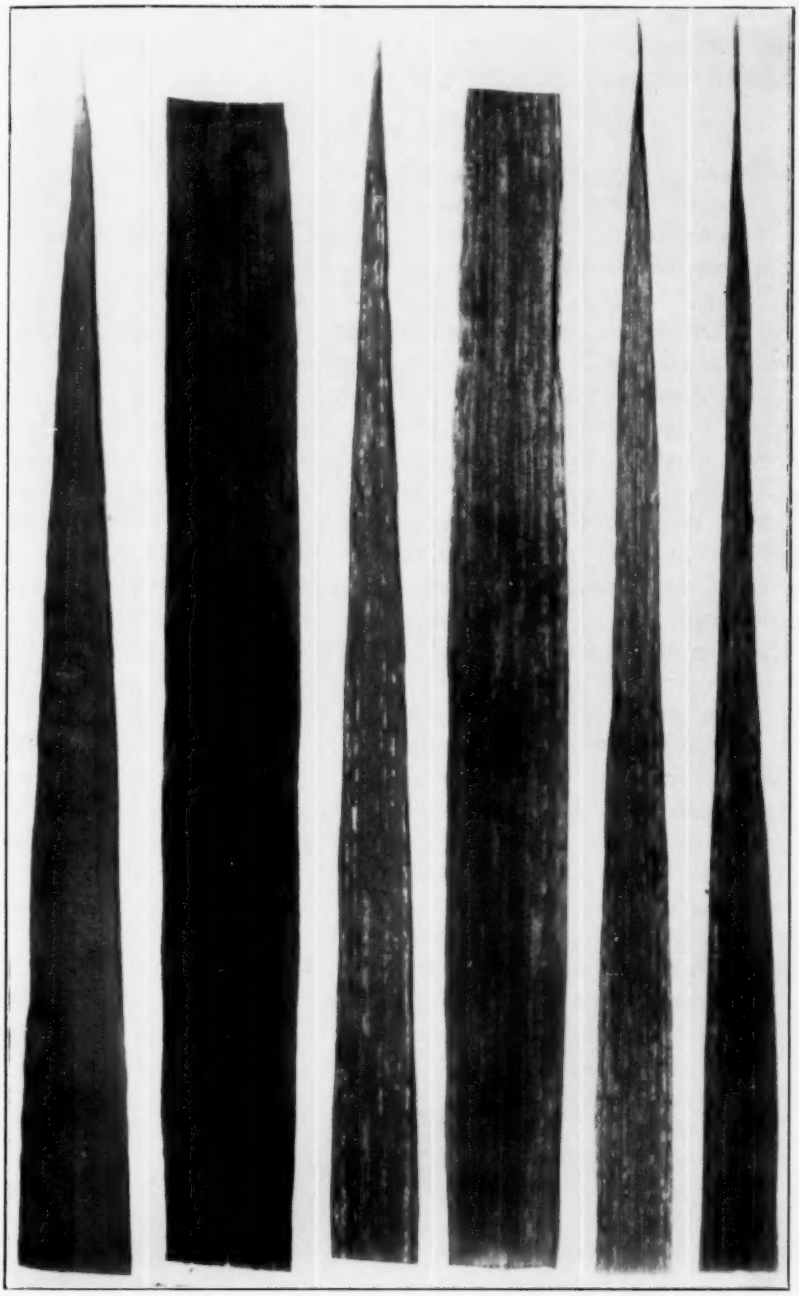

FIG. 3. Apical mosaic in leaves of Letoria oats, induced by manual inoculation. The two segments at left illustrate one healthy leaf; the third and fourth segments illustrate one mosaic leaf (both leaves removed just above their ligules). The remaining two segments illustrate the distal halves of mosaic leaves; the proximal halves, not shown, had little or no mottling. (Mag. $\times 1$.)

areas that have been under the writer's observation in the Carolinas, Georgia, and Alabama, and some isolates have induced extremely mild chlorosis in comparison with the type virus.

Eyespot-mosaic Virus

In 1944, eyespot symptoms were noted in all of the mosaic oat fields observed by the writer, but they were complicated with the symptoms of the chlorotic lines and mottling of apical mosaic. In 1945, very little of the eyespot reaction was evident, but some was observed in all of the experimental plats.

The isolate here described originated from a plant growing in the virus-infested soil collected at Auburn, Ala. In Letoria and Victoria × Rainbow oats the fusiform spots or eyespots are essentially comparable with the rings associated with many mosaics of dicotyledonous species. The linear arrangement of the main vascular elements in the grasses doubtless accounts for the fusiform or spindle shape of these spots. The borders of the eyespots and other chlorotic areas frequently become ashen gray, due to the loss of the yellow pigments, and the centers of the eyespots tend to remain green until the normal green portions of the leaf become chlorotic. The spots are most pronounced in leaves that have completed or nearly completed their growth; and in the younger leaves the spotting is more evident in the older or distal portion than it is in the proximal portion. Mottling sometimes appears on the leaf sheaths, but this has been less common with this virus than it has been with the apical mosaic virus. Anthocyanins sometimes develop causing red and purple patterns. Senility is hastened in the diseased leaves. Mosaic leaves of Letoria are illustrated in figure 4.

The observations made to date suggest that the eyespot virus continues to invade the leaf tissues for a longer period than does the apical-mosaic virus. Also, the eyespot symptoms tend to be persistent in the leaves, whereas the symptoms of the apical mosaic are very transitory and are seldom evident in the older leaves of the two oat varieties studied. On the other hand, as the greenhouse temperatures rose in the spring, it was observed that the eyespot mosaic failed to appear in the new leaves sooner than the apical mosaic.

NOMENCLATURE OF THE VIRUSES

Marmor **terrestre** sp. nov.

Specific name from Latin *terrestris*, adj., of the earth, referring to the association of the species with soil.

Host reactions: In *Avena sativa* L., and *A. byzantina* C. Koch, induces chlorotic mottling, streaking, or spotting in varying degrees from mild to severe. *Triticum aestivum* L., has failed to express mosaic in the field when sown in soil infested with *Marmor terrestre*, but when inoculated manually with the type variety of the virus, 2 out of 50 inoculated plants of Michigan Amber wheat expressed mosaic. *Zea mays* L., appears to be immune.

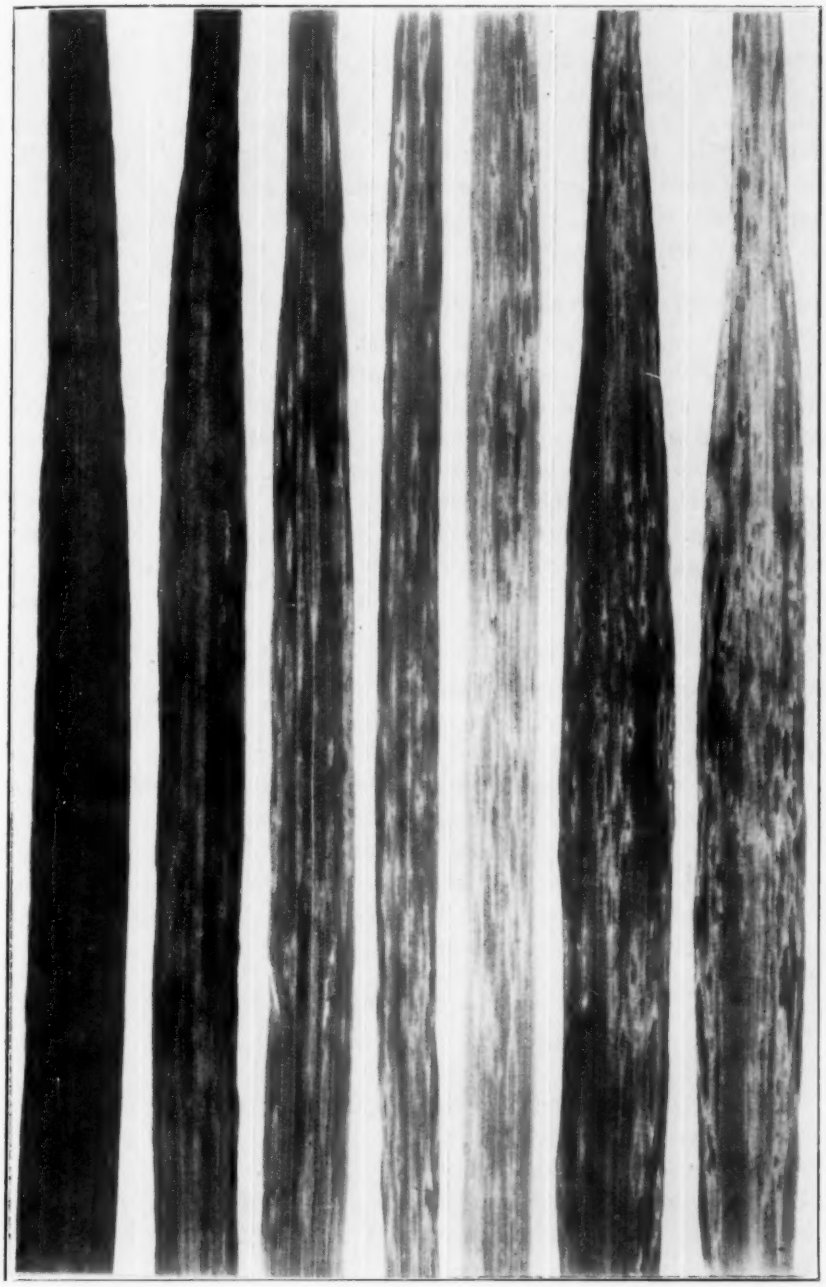

FIG. 4. Eyespot mosaic in segments of leaves of Letoria oats, induced by manual inoculation. Leaf segment from a healthy plant at left. (Mag. × 1.)

Transmission: By inoculation with expressed juice, using the carborundum wiping method, but with difficulty. The incubation period has ranged from 11 to 70 days. This species overseasons in the soil. Infection from the soil has occurred within 35 to 60 days after seeding when plants were cultured out of doors during the autumn and early winter at Beltsville, Md. Mosaic symptoms were expressed when the infected plants were transferred to a greenhouse with the temperature near 65° F. In culture chambers, 60° has been more favorable than 65° F., for infection from the soil, but 65° has been more favorable for the expression of mosaic.

Marmor terrestre, var. **typicum,** var. nov.

Common name: Oat apical-mosaic virus.

Host reactions: In *Avena spp.*, agronomic varieties Letoria and Victoria × Rainbow, cultured at 60°–65° F., the virus induces light-green to yellow dashes and streaks parallelling the long axis of the leaf, and sometimes chlorotic mottling. Chlorotic patterns usually most evident in or near the apical portions of the three upper leaves, tending to fade as the leaves develop. As temperatures reach 75° F., and above, the symptoms become weak and fail to appear in the new foliage. Mosaic leaves are illustrated in figure 3.

Marmor terrestre var. **oculatum,** var. nov.

Common name: Oat eyespot mosaic.

Varietal name from Latin, *oculatus,* adj., eyed, with eye-like marks.

Host reactions: In *Avena spp.*, agronomic varieties Letoria and Victoria × Rainbow, cultured at 60°–65° F., virus induces chlorotic spots and diffuse chlorotic patches. The characteristic eyespots are fusiform or spindle shaped with light-green to ashen-gray borders and green centers. They are most pronounced in leaves that have completed or nearly completed their growth. In the younger leaves the spotting is most evident in the older portions. Mosaic leaves are illustrated in figure 4.

SUMMARY

1. Two mosaics of winter oats occur in limited areas in the Carolinas, Georgia, and Alabama.

2. Manual transmission has been effected by the carborundum-wipe method, but with difficulty.

3. The viruses overseason in the soil.

4. The viruses have not infected wheat in the field, and only one has infected wheat slightly when inoculated manually. None have infected corn.

5. Temperatures near 60° F. for 35 to 60 days seem to be near the optimum for infection through the soil, but 65° F. seems to be near the optimum for the best expression of chlorosis. A temperature of 65° F. has been rather favorable for infection from manual inoculations, and 60° F.

seems to be near the optimum for culturing the seedlings previous to inoculation.

6. The disease caused greater damage to the infected plants in 1944 than in 1945, although the amount of infection seemed to be just as great in 1945. Temperatures were unusually high early in the spring of 1945, which may account for the reduced damage.

PLANT INDUSTRY STATION,
BELTSVILLE, MARYLAND.

POWDERY MILDEW OF BROAD BEAN CAUSED BY ERYSIPHE POLYGONI DC. IN YUNNAN, CHINA[1]

T. F. Yu

(Accepted for publication January 30, 1946)

Powdery mildew of broad bean (*Vicia faba* L.) caused by *Erysiphe polygoni* DC. was first collected by the writer on broad bean in Hui-li, Szechwan, in the spring of 1938. Since then it has been found in many places in southwestern China, particularly in Yunnan (7), where the disease is widely distributed and has caused damage for several years in some of the bean-growing sections. This paper presents the results of three years' work on the disease, which, so far as the writer is aware, does not occur, or at least has not been reported yet in the other important bean-growing regions of China.

DISTRIBUTION AND ECONOMIC IMPORTANCE

In Yunnan Province, the disease is of variable importance in different localities. In the northern bean-growing sections, the disease has developed too late in the season to cause appreciable loss; while in the south it is usually present each season and may cause conspicuous blight of stem tips and prematurity of the young pods. In general, the disease is not of great economic importance.

SYMPTOMS

The disease occurs in early spring when the flowering buds have appeared. After a few leaves become covered with mildew, a general infection may occur in the whole plant within a week under favorable conditions.

Small, white, powdery spots appear on the leaves, enlarge rapidly, coalesce to form large areas, and finally cover the entire leaf. Both the upper and lower surfaces of the leaves may become infected. When very young leaves are attacked, they become stunted before attaining one-half their normal size. They usually remain folded longitudinally and at the same time become abnormally thickened. As the disease progresses, these young top leaves become discolored and withered, which results in a blight of stem tips. When old leaves become infected, there is no malformation of the tissues. On infected leaves, both young and old, reddish spots or lesions frequently occur in addition to the characteristic superficial white growth of the fungus.

After the foliage is infected, young stems and petioles become infected. The copious or scant white powdery fungus covers the affected parts and red lesions are common. Old stems, however, are only rarely infected.

[1] Paper No. 30 from Division of Plant Pathology, Institute of Agricultural Research, Tsing Hua University, Kunming, China.

The writer is indebted to Professor F. L. Tai for reading over the manuscript.

Pods are frequently attacked throughout the growing period of the plant. On old pods, the fungus produces red spots or lesions with or without macroscopic mycelial growth. Young pods, on the other hand, may be severely attacked and they become deformed or ripen prematurely.

In the field, the young leaves are stunted and deformed, affected stem tips are either stunted or killed back, and pods may be lacking or may ripen prematurely.

INOCULATIONS

Potted greenhouse plants were inoculated. They were first atomized with a fine spray of water, then small portions of a young stem bearing a few diseased leaves were laid on, and in contact with, the healthy leaves. Inoculated plants were kept in a moist chamber for 24 to 48 hours. Notes were taken when the development of the disease had reached its maximum stage, usually 7 to 14 days after inoculation.

In March, 1940, four broad bean plants were inoculated with conidia taken from broad beans. Eight days later, all were infected. In another experiment, mildew appeared on 8 of 11 plants 10 days after inoculation. In still another experiment, 24 of 25 plants were infected. Numerous other inoculations were made during subsequent years. Only in rare cases, did the fungus fail to infect the bean plants.

The symptoms on the inoculated plants were somewhat variable at different times of the year. In general, the disease first appeared as grayish white powdery spots which soon covered the entire leaf surface. In certain instances, development of the fungus was rather meager, and it formed only a very thin layer of mycelium just visible to the naked eye. In this case, red lesions were frequent underneath or marginal to the mycelium. Occasionally, only small red spots were seen on the inoculated plants. Young leaves might be killed during the later stages of the disease.

CAUSAL FUNGUS

Powdery mildew of broad bean in Yunnan is caused by *Erysiphe polygoni* DC.

Conidia are borne singly or in short, 2-spore chains on the conidiophores. They are ovate to oblong with round ends, average 38.3 μ long by 19.1 μ wide, and vary from 27.9 to 47.0 μ long and from 12.2 to 22.6 μ wide. Conidiophores measure 20.4 to 68 μ by 6.8 to 8.5 μ and are composed of 2 to 4 cells.

Perithecia are dark brown, globose, and scattered on the mycelium. They are 79.9 to 119 μ in diameter, with an average of 98.6 μ. Appendages are rudimentary, short and brown, mostly 40 to 48 μ long and 6 to 8 μ wide. Asci, varying from 4 to 8, are ovate to broad ovate and are from 30 to 62.6 μ in length and from 22.6 to 41.8 μ in width, with an average of 50.9 by 31 μ. Ascospores, 3 to 8, are ovate or longer, broadest in the middle, average 19.5 by 12 μ, and range from 13.9 to 24.4 by 10.4 to 15.7 μ.

Conidia germinate in a wide range of temperature, from 16° to 28° C., within 48 hours. However, they germinate best between 20° and 24° C.

A high relative humidity is essential for the germination of conidia. Fresh spores, placed on dry glass slides in containers with different percentages of relative humidity and incubated at favorable temperatures, germinate only when the humidity is maintained at 90 per cent or above. Very few spores germinate when they are in drops of water. Conidia are generally short-lived. Under the conditions of the present investigation, they were viable only 2 or 3 days in the laboratory.

RELATION OF WEATHER TO DISEASE DEVELOPMENT

The development of powdery mildew may be correlated with weather conditions in Yunnan, because the disease occurs every year on broad bean in the southern part of the Province, but seldom appears in the northern part except on late crops of beans.

In Yunnan, a dry and a wet season occur every year. Roughly speaking, the dry season lasts 7 months, from the middle of October to the first part of June. It is in this dry season that broad beans are grown. In the southern part of the Province the crops are generally harvested between the end of March and the first part of May, while in the north the harvesting is one to one and a half months later. It is especially dry from December to April. The average monthly precipitation throughout this period seldom exceeds 70 mm. in almost all the bean-growing regions. There is, however, wide variation between day and night temperatures which brings on a regular dew formation that favors infection and the establishment of the mildew organism. Apparently, humidity is not the factor that will limit the occurrence of the disease in all of these bean-growing regions.

The air temperatures in the different regions are, on the other hand, extremely variable according to the elevation as well as the latitude. Studies, surveys, and observations in 1940, and subsequent years, have demonstrated a correlation between air temperature and the occurrence of the disease. As shown in table 1, powdery mildew was observed early in February at Kai-yuen. At that time, the average monthly air temperature was 20.4° C. In Chengkiang and Tsu-hsiun, diseased beans were found in April, when the average air temperatures were, respectively, 21.7° and 21.4° C. At Ta-li and Kunming, however, where average air temperatures usually were below

TABLE 1.—*Occurrence of powdery mildew of broad bean in relation to air temperatures at five localities in Yunnan in 1940*

Locality	Month in which disease was observed	Average monthly air temperature in degrees centigrade					
		Jan.	Feb.	Mar.	Apr.	May	June
Kai-yuen	Feb.–March	20.5	20.5	22.4	22.3	23.8	23.2
Chengkiang	March–April	14.7	14.7	19.1	21.7	25.8	25.3
Tsu-hsiun	March–April	19.2	19.4	20.3	21.4	22.2	23.1
Kunming	May–July[a]	9.8	11.3	14.2	18.0	19.5	19.6
Tai-li	May–July[a]	10.7	11.4	16.1	18.2	19.4	21.7

[a] On volunteer bean plants left in the field.

20° C., disease seldom appeared on the regular crop but was seen from May to July on volunteer plants left in the field or on certain late crops.

An experiment was made in the winter of 1942 to determine the relation of air temperature to the development of the disease. Young stems bearing a few healthy leaves were detached from bean plants, inoculated with conidia, and placed with bases in small flasks of water in chambers at different temperatures. At the end of three days, conspicuous mycelium of the fungus was seen on the leaves held at 20° C. to 24° C. Those held at 18° C. or below produced slight or no mycelium at all during the 7 days of the experiment. Although the experiments were preliminary, the results obtained seem to substantiate the observations made in the field that a relatively high air temperature during the spring favors the development of the disease in Yunnan.

HOST RANGE AND PHYSIOLOGIC SPECIALIZATION

It has been demonstrated by Salmon (5), Hammerlund (3), Blumer (1, 2), Searle (6), and others that *Erysiphe polygoni* DC. em. Salm. comprises a large number of physiologic races that differ from one another in pathogenicity. In most cases, each race is confined to a single species or to a few closely related species of the host and seldom has power to infect other genera.

Hammerlund (3) and Blumer (1, 2) independently investigated the specialization of parasitism in *Erysiphe polygoni* DC. Hammerlund distinguished 26 "form species" of this fungus. Among them, the following are found on the leguminous plants: f. sp. *medicagensis-sativae* on *Medicago sativa* and *M. falcata;* f. sp. *meliloti* on three species of *Melilotus;* f. sp. *trifolii repentis* on *Trifolium repens;* f. sp. *trifolii pratensis* on *Trifolium pratense* and *T. medium;* f. sp. *vicia-sativae* on *Vicia sativa* and other species of *Vicia;* f. sp. *pisi* on *Pisum sativum* and *P. arvense.*

Blumer (2) divided *Erysiphe polygoni* DC. em. Salm. into several species. Of these, *Erysiphe pisi* DC. attacks species of *Pisum, Dorycnium, Medicago, Lupinus,* and *Vicia* among the Leguminosae. According to his own investigation and the infection experiments of both Salmon and Hammerlund, Blumer set up 4 "form species" in *Erysiphe pisi* DC.: f. sp. *pisi* Hammerlund on *Pisum sativum;* f. sp. *medicaginis sativae* Hammerlund on *Medicago sativa* and *M. falcata;* f. sp. *medicaginis lupulinae* Hammerlund on *Medicago lupulina;* and f. sp. *viciae sativa* Hammerlund on *Vicia sativa, V. sepium* and *V. silvatica.* Blumer stated that there might exist another "form species" on the genus *Vicia* although the specialization of its parasitism was not then clear. Searle (6), early in 1920, studied physiologic specialization in *Erysiphe polygoni* DC. on certain kinds of host plants. He showed that the fungi on *Polygonum aviculare, Trifolium pratense,* and *Pisum sativum* are distinct physiologic races. In one series of his inoculation experiments, conidia from *Pisum sativum* were used to inoculate *Pisum sativum, Onobrychis sativa, Vicia faba,* and *Trifolium pratense.* His results

indicated that conidia from *Pisum sativum* were unable to infect any of these plants; the fungus is said to be specialized on its own host, *P. sativum*. This confirms the fact, already noted by Salmon (5), that *Erysiphe polygoni* DC. on *Pisum sativum* is a distinct physiologic race and is unable to cause infection on *Vicia faba*.

From these investigations, it is known that *Erysiphe polygoni* DC. on *Pisum sativum* is a physiologic race distinct from the race attacking species of *Vicia*, while the *Erysiphe polygoni* on the different species of *Vicia* probably comprise a single race.

On account of the favorable weather conditions, *Erysiphe polygoni* DC. has been observed on a number of different host plants in this part of China. Material was available, therefore, for cross-inoculation experiments with the fungi collected from the various Leguminosae.

The first series of inoculations was with conidia from *Pisum sativum*, *Vicia faba*, and *Lathyrus quinquenervius*. In order to avoid contamination, the tests were made in separate greenhouses. The method of inoculation was the same as described. In table 2 the ++ sign denotes abundant mycelium accompanied by abundant sporulation, +− denotes trace to moderate mycelium accompanied by red spots or lesions, and the 0 denotes no macroscopically evident mycelium.

TABLE 2.—*Cross-inoculation experiments with conidia from Pisum sativum, Vicia faba, and Lathyrus quinquenervius in 1941 and 1942*

Conidia from	Host inoculated					
	Pisum sativum		*Vicia faba*		*Lathyrus quinquenervius*	
	No. inoculated	No. infected	No. inoculated	No. infected	No. inoculated	No. infected
Pisum sativum	16	16++	20	18+−	12	12 (0)
Vicia faba	20	19++	16	14+−	15	15 (0)
Lathyrus quinquenervius	6	6 (0)	7	7 (0)	10	10+−

The results indicate, contrary to the results obtained by the previous investigators, that the fungus from *Pisum sativum* is able to cause infection on both *Pisum sativum* and *Vicia faba*, and the same is true for the fungus from *Vicia faba*. Evidently, the two should be regarded as the same physiologic race, whereas that from *Lathyrus quinquenervius* is a distinct race.

In examining the types of infection produced by conidia from either *Pisum sativum* or *Vicia faba*, it was noted that, in most cases, the mycelium was much scantier on *Vicia faba* than on *Pisum sativum*. Inasmuch as the identity of the two cultures has been proved by cross-inoculation experiments, it is suggested that the difference in degree of infection on the two hosts was probably due to a difference in the nature of host plants rather than in the fungi themselves. In other words, the beans are more resistant to the attack of the fungus than the peas.

The second series of cross inoculations was conducted with an attempt to determine the pathogenicity of *Erysiphe polygoni* DC. collected from the various species of *Vicia*, including *Vicia cracca, V. faba, V. hirsuta, V. sepium*, and *V. tetrasperma*, all of which are commonly mildewed in Kunming and its vicinity. In addition, seeds of many other species of *Vicia* were obtained through the kindness of the United States Department of Agriculture, Kew Gardens in England, and various institutes in China. These seeds were sown in small plots each fall since 1940. *Erysiphe polygoni* DC. has been found on all of them and material was collected from these plots for cross inoculations.

In the winter of 1940, 1941, and 1942, healthy seedlings of *Vicia angustifolia, V. atropurpurea, V. cracca, V. dasycarpa, V. faba, V. gigantea, V. hirsuta, V. leucantha, V. lutea, V. monantha, V. orobus, V. pannonica, V. sativa, V. sepium, V. tetrasperma, V. tridentata*, and *V. villosa* were raised in a clean greenhouse. Cross inoculations were made to potted plants in other greenhouses and were repeated to insure the development of the disease. In order to avoid contamination, the inoculated seedlings were left in large glass chimneys covered with a thin layer of cotton at the top. The results of these experiments indicated that conidia taken from any of these species of *Vicia* were capable of infecting all of the other species used. These cultures are, therefore, regarded as a single physiologic race of *Erysiphe polygoni* DC. and are considered to be the same race that has been found on *Pisum sativum* in this part of China.

The reactions of these *Vicia* host plants to the attack of the fungus were by no means alike in these experiments. Many of the species seemed more susceptible to the disease than the others. For example, on *Vicia orobus* the fungus usually produced an abundant mycelium and abundant spores, and it rarely formed red lesions as it did on *V. faba*.

The term physiologic race is generally used to refer to strains of the fungus which are morphologically indistinguishable. However, in certain species of *Erysiphe* the so-called physiologic races can be differentiated from one another by the morphology of either the conidia or the perithecia. Blumer (2), for instance, has distinguished *Erysiphe pisi* on *Medicago, Pisum*, and *Vicia* by the size of perithecia. Homma (4) has made a comparative study, based on the difference in conidial dimensions, of the various physiologic races of *Erysiphe graminis* DC. and has found that there are appreciable morphological differences between the races on common wheat, naked barley, *Poa annua*, and *Elymus mollis*. Yarwood (8) has also shown that the forms of *Erysiphe polygoni* DC. on bean, red clover, California poppy, mustard, pea, cowpea, buckwheat, and Columbine can be distinguished readily from each other by the gross morphology of their conidiophores and conidia.

One hundred viable conidia of the mildew fungus from each of the various species of *Vicia*, and from *Pisum sativum* were measured while mounted in water under cover slips (Table 3).

No decided constant differences were noted in the size and shape of conidia taken from any of these host plants. This is further evidence that the powdery mildew of *Vicia* species and of *Pisum sativum* in Yunnan is caused by the same physiologic race of *Erysiphe polygoni* DC.

Since the fungus is able to infect both peas and broad beans in China, then to which "form species," *viz. pisi* or *viciae sativa* given by Blumer is it more related? Indeed, in the infection experiments, the peas were more susceptible to the attack of the fungus than the beans. However, many other species of *Vicia*, such as *V. orobus* and *V. gigantea* were equally, if not more, susceptible to the disease than peas. Evidently, the difference in degree of susceptibility of the hosts has nothing to do with the question. In case of morphologic difference, Blumer (2) distinguished the form species of *Erysiphe pisi* DC. on *Medicago sativa*, *Vicia sativa*, and *Pisum sativum* by

TABLE 3.—*Measurements of conidia of Erysiphe polygoni DC. from naturally infected Vicia species and from Pisum sativum*

Host	Range for conidia, in μ		Average, in μ
	Length	Width	
Vicia atropurpurea	27.8–45.3	13.9–20.9	36.7 × 17.4
V. cracca	29.6–48.7	13.9–20.9	37.8 × 17.0
V. dasycarpa	33.1–47.0	15.7–20.9	39.7 × 18.4
V. faba	27.9–47.0	12.2–22.6	38.3 × 19.1
V. gigantea	27.7–43.5	13.9–20.9	37.6 × 17.4
V. hirsuta	29.6–47.0	13.9–20.9	37.9 × 17.8
V. lutea	26.1–48.7	12.2–19.1	36.9 × 17.2
V. monantha	29.6–43.5	15.7–22.6	36.7 × 19.0
V. orobus	26.1–43.5	13.9–20.9	35.4 × 16.9
V. pannonica	31.3–48.7	13.9–20.9	39.1 × 18.1
V. sativa	27.9–45.6	13.3–22.6	36.5 × 18.8
V. sepium	27.9–47.0	13.9–20.9	39.4 × 17.6
V. tetrasperma	29.6–48.7	13.9–20.9	37.9 × 16.8
V. villosa	27.9–48.7	13.9–20.9	35.7 × 18.3
Pisum sativum	31.3–48.7	13.9–20.9	38.5 × 18.6

the size of their respective perithecia. According to his measurements, the perithecia of the fungus on *Vicia* and on *Pisum* were similar: Perithecia from *Vicia* ranged from 97 to 119 μ in diameter with an average of 108.3 μ, and those from *Pisum* ranged from 102 to 126 μ with an average of 114.4 μ. The perithecia of the fungus on *Medicago sativa* were decidedly smaller, from 85 to 101 μ in diameter with an average of 93.2 μ. The perithecia measurements of the fungus in China, as given before, are closer to those of perithecia from *Vicia sativum* than those from *Pisum sativum* as given by Blumer. It is therefore justified to consider the fungus in China as a new form of *Erysiphe polygoni* DC. parasitizing both the species of *Vicia* and *Pisum*, and f. sp. *viciae pisi* is accordingly proposed in order to distinguish it from f. sp. *viciae sativae* Hammerlund (Blumer) which occurs only on the genus *Vicia*. The present race is also known to be distinct from f. sp. *pisi* Hammerlund (Blumer) by reason of its ability to infect *Vicia* in addition to infecting *Pisum*.

METHODS OF OVERWINTERING

Studies made by the writer during the past three years have shown that the powdery mildew of broad bean may overwinter either as conidia or perithecia on beans, peas, or wild species of *Vicia*.

Mature perithecia containing asci with ascospores were occasionally observed on *Vicia sativa* in the spring. No perithecia were found on beans and peas in nature.

In southern Yunnan, the winters are so mild that many wild species of *Vicia*, such as *Vicia sativa* and *V. hirsuta*, usually survive the winter. Conidia are found on them in the early spring.

It is also interesting to point out that in certain districts of southern Yunnan, two crops of beans are raised. The second crop, primarily for table use, is spring-sown and is harvested during November, December, and January of the next year. Conidia have been found on them even in the winter months. Evidently, this second crop serves as the source of infection for the fall-sown beans.

DISCUSSION

Field observations and laboratory experiments have revealed that the occurrence of *Erysiphe polygoni* DC. in Yunnan seems to be correlated with air temperatures. The disease rarely occurs in those regions where the average monthly air temperature during the later stages of plant development is below 20° C. However, it is surprising to find that powdery mildew of pea is not only coexistent with the crop but is also present in winter when the average air temperature rarely exceeds 16° C. in most of the pea-growing districts. Since the fungus on peas and beans constitutes a single physiologic race of *Erysiphe polygoni* DC., it is hard to give reasons why the air temperature will limit the development of the fungus on one kind of host and not on the other. It seems, therefore, that in the studies on the environmental factors in relation to the occurrence of a disease, the nature of the host plants should also be taken into consideration. This assumption, although a matter of speculation, is, nevertheless, of some interest.

SUMMARY

Powdery mildew of broad bean, caused by *Erysiphe polygoni* DC., is very prevalent in the bean-growing regions of southern Yunnan Province in China. Although it is of no great economic importance, it occasionally damages the crop.

Leaves, petioles, stems, and pods of plants are attacked. Only in severe cases, does mildew blight the stem tips and cause premature ripening of young pods.

In contradiction to the results obtained by previous investigators, the mildew fungus on broad beans is able to cause infection on *Pisum sativum*. Based on this finding, powdery mildews of broad beans and peas in Yunnan is considered to be caused by a single physiologic race and is herein desig-

nated as *Erysiphe polygoni* DC. *viciae pisi* forma nova., a race which differs from f. sp. *vicia-sativae* Hammerlund by its ability to infect *Pisum sativum*. Powdery mildew on *Lathyrus quinquenervius* is a distinct race.

The occurrence of the disease is correlated with relatively high air temperatures during March, April, and May. An average monthly temperature of 20° C. or above favors the development of the disease on broad bean.

The fungus is capable of overwintering as either conidia or perithecia on beans and peas as well as on the wild species of *Vicia*.

TSING HUA UNIVERSITY,
KUNMING, CHINA.

LITERATURE CITED

1. BLUMER, S. Infektionsversuche mit Erysiphaceen. Centralblatt für Bakt. Abt. II 65: 62–70. 1925.
2. ———. Die Erysiphaceen Mitteleuropas, mit besonderer Berucksichtigung der Schweiz. 483 pp. Zurich. 1933.
3. HAMMERLUND, C. Zur Genetik, Biologie und Physiologie einiger Erysiphaceen. Hereditas 6: 1–126. 1925.
4. HOMMA, Y. A statistical study on the biological forms of *Erysiphe graminis* DC. Sapporo Nat. Hist. Soc. Trans. 10: 157–161. (In Japanese with English resume.) 1929.
5. SALMON, E. S. On specialization of parasitism in the Erysiphaceae. Bot. Centbl. Beihefte 14: 261–315. 1903.
6. SEARLE, G. O. Some observations on *Erysiphe polygoni* DC. Trans. Brit. Mycol. Soc. 6: 274–293. 1920.
7. TAI, F. L. A preliminary list of economic plant diseases of Yunnan. Bul. 6. Inst. Agric. Research, National Tsing Hua University. (In Chinese with English resume.) 1941.
8. YARWOOD, C. E. Host range and physiologic specialization of red clover powdery mildew, *Erysiphe polygoni*. Jour. Agr. Res. [U.S.] 52: 659–665. 1936.

PHYTOPATHOLOGICAL NOTES

Perithecia of Powdery Mildew on Zinnia Seed.—There are few records of the occurrence or transmission of powdery mildews on seeds. *Erysiphe polygoni* DC. has been reported as externally and internally borne by pea seed[1,2,3] and externally carried on seed of *Cuminum cyminum.*[4] Circumstantial evidence has been presented[5] that *E. cichoracearum* DC. was carried on cineraria seed, and it was suspected[6] that *E. Fischeri* Blumer on *Senecio* spp. and *E. horridula* (Wallr.) Lév. on *Myosotis* were transmitted on seed.

In several commercial zinnia seed fields in Ventura and Santa Barbara Counties, California, in which powdery mildew had not been controlled effectively, the fungus, *E. cichoracearum,* developed copiously in the flower heads and there formed abundant perithecia in October, 1943, particularly on the

TABLE 1.—*Incidence of perithecia of Erysiphe cichoracearum on zinnia seed hand-picked and threshed by hand or machinery (1943)*

Variety	Lot number and handling of seed	Number seeds examined	Percentage seeds	
			With 10–100 perithecia	With 1–9 perithecia
Oriole	1. Picked in September; hand-threshed	488	2.66	11.68
do	2. Picked in October; hand-threshed	4,690	1.07	5.57
do	3. Picked in October; hand-threshed	3,034	1.42	5.11
do	4. Picked in October; commercially threshed and cleaned	9,253	0.34	1.97
Mixed	5. Picked in September; hand-threshed	3,396	0.29	1.71
Total or average		20,861	0.70	3.42

variety Giant Dahlia Flowered Oriole. Perithecia were most abundant at the stylar end of the seed and usually were formed at the lower edge of petal infections which extended onto the immature seed (achene). The cup formed at the stylar end of zinnia seed by the petal base provides a protected cavity in which microorganisms can be carried.

The incidence of perithecia on zinnia seeds handled in various ways is shown in table 1. Lots 1, 2, 3, and 5 were carefully picked and the chaff removed by hand in the laboratory. Lot 4, commercially hand-picked, dried on canvas, machine-threshed, and machine-cleaned, still carried perithecia on 2.31 per cent of the seed.

[1] Van Hook, J. M. Powdery mildew of the pea. Ohio Agr. Exp. Sta. Bull. 173: 247–249. 1906.

[2] Crawford, R. F. Powdery mildew of peas. New Mexico Agr. Exp. Sta. Bull. 163. 1927.

[3] Uppal, B. N., M. K. Patel, and M. N. Kamat. Pea powdery mildew in Bombay. Bombay Dept. Agr. Bull. 177. 1935.

[4] Uppal, B. N., and M. K. Desai. Cumin powdery mildew in Bombay. Bombay Dept. Agr. Bull. 169. 1933.

[5] Macdonald, J. A. Powdery mildew on cinerarias. Gard. Chron. **105**(2721): 111. 1939.

[6] Blumer, S. Die Erysiphaceen Mitteleuropas mit besonderer Berücksichtigung der Schweiz. *In* Beiträge zur Kryptogamenflora der Schweiz **7**(1): 46. 1933.

Samples of these lots were grown in flats of sterilized soil in the greenhouse for 6 weeks the following spring, but no mildew ever developed on the plants. Perithecia were still present, although in reduced numbers, on the seed coats after they had been pushed through the soil in germination. Apparently the ascospores were not released or, if any were, did not infect. This is not surprising in view of the difficulties which have been reported by various workers in germination of ascospores of powdery mildews. However, it is possible that infection rarely occurs from perithecia of powdery mildew on zinnia seed.

Powdery mildew perithecia on seeds such as zinnia, which have epigeal germination, would be in a much more favorable position for producing ascospore infection than those on seeds such as pea, which have hypogeal germination. The internal infection described for pea seed would, of course, represent a different phenomenon.

Powdery mildew is relatively easy to control in commercial zinnia seed fields in California by frequent and consistent dusting with sulphur unless infections become established in the flower heads. Such infections may greatly reduce yield and quality of seed, as well as lead to the possibility of seed transmission. Emphasis on control early in the season to prevent flower infection is indicated.—KENNETH F. BAKER and WARREN F. LOCKE, Division of Plant Pathology, University of California, Los Angeles.

Camellia Flower Blight.—In 1940, a camellia flower blight was described as new[1] and the causal fungus was designated *Sclerotinia Camelliae*. Professor Iwao Hino of Miyazaki College of Agriculture later called to our attention the fact that Mr. K. Hara had described[2, 3] what appeared to be the same disease and fungus in Japan about twenty years earlier. While Hara's dimensions for asci ($120–140 \times 6–8\ \mu$) and ascospores ($8–11 \times 4–5\ \mu$) are somewhat larger than ours ($100–125 \times 4.3–5.8$ and $5.3–7 \times 2.5–3.5$), it appears that the fungus here is essentially the same as that in Japan and should be designated hereafter as *S. Camelliae* Hara.

It is probable moreover that the fungus was introduced into the United States from Japan as suggested in our earlier report[1] in view of the above additional evidence and the further fact that the disease has since been found in California in a second nursery which imported plants from Japan.

All told the disease has been found in several other nurseries and parks and in a few private gardens in California. Apparently it is not definitely known to be established elsewhere in the United States.

Although considerable effort was expended in removal and destruction of affected flowers in the nursery where the disease was first seen in 1938, there were numerous infected flowers in 1943 and 1944. This nursery com-

[1] Hansen, H. N., and H. Earl Thomas. Flower blight of camellias. Phytopath. **30**: 166–170. 1940.

[2] Hara, Kanesuke. [On a Sclerotinia disease of Camellia.] Dainippon Sanrinkwaihô No. 436. pp. 29–31. 1919. (In Japanese.)

[3] Hara, Kanesuke. [Sclerotinia disease of Camellia.] Zikken Zyumoku Byôgihen. pp. 251–252. 1927.

prises several acres and the problem of eradicating the disease is further complicated by the practice of maintaining numerous plants in containers of assorted sizes and shapes, which may afford concealment for some of the sclerotia. However, in 1944 the nursery, in addition to destroying infected flowers, began ground-spraying with Fermate. Whether the spraying contributed to the result is not yet clear. At any rate the disease in 1945 was limited to two small areas, the largest only a few yards in diameter. A preliminary test on some of the buried sclerotia, indicated that Fermate at 4 lb. in 100 gallons did not kill mature apothecia but seemed to inhibit formation of additional apothecia.

Since wholesale disbudding for one or more years was under consideration as an alternative control measure, some information on the interval between sclerotium formation and the production of apothecia was needed. Accordingly in April, 1943, whole blighted flowers and petals separated from such flowers were placed on soil in boxes and covered about one inch deep by peat moss and placed under lath. Sclerotia collected in 1938 and kept dry until the beginning of this experiment were similarly buried. The moss was kept continuously wet thereafter. On February 24, 1944, apothecia were found in the box containing whole flowers and in the box in which petals had been buried. No apothecia arose from the old sclerotia at that time or afterward. Apothecia were produced in greater numbers and over a longer period from the whole flowers than from separate petals, the last apothecia for 1944 appearing about mid-April. A few sclerotia from whole flowers were removed and examined on May 13, 1944, and found to be firm, although one of them had produced several apothecia. The remainder were left undisturbed until the spring of 1945, the medium having been kept moist continuously. The first apothecia were found on February 6, 1945, in the box with whole flowers and the last[4] about April 15. No apothecia appeared in 1945 in the box containing petals only.

In an attempt to determine whether the fungus is able to invade unopened flowers, several large plants with numerous flower buds were placed under glass at a distance from the nursery. All buds with petals exposed at the time the plants were moved were marked at that time, and only those buds developed symptoms of the disease.

Since only the ascospores are infective and only flowers are infected, it should be possible to eliminate the fungus altogether by systematic destruction of infected flowers possibly supplemented by ground spraying.

In the meantime discretion should be observed in the movement of balled or boxed plants from infested to noninfested areas.—H. EARL THOMAS and H. N. HANSEN, Division of Plant Pathology, University of California, Berkeley, California.

Yellow Berry and Stem Rust of Wheat.—Under Palestinian conditions only a few varieties of imported vulgare wheats (CCC, BIPM, Giza 7) bear starchy kernels. Almost all indigenous durum and imported durum and

[4] While this note was in press apothecia appeared again early in February, 1946.

vulgare wheats bear normally characteristic flinty kernels. However, not infrequently, kernels affected with yellow spots may be found among the flinty kernels. This phenomenon is characteristic for either durum varieties moderately resistant to rust, or vulgare varieties that usually escape rust, both under conditions of rust attack.

In field trials with the control of wheat rusts by sulphur dusts,[1] it was observed that treated plants yielded only 0.2 per cent kernels affected with yellow spots, while the nondusted rusted plants yielded from 5 to 63 per cent, the average of such affected grains being 24 per cent. It is apparent, therefore, that yellow spotted kernels may be connected with rust attack of plants.

The analysis of kernels from rusted plants revealed a lower weight, lower protein and gluten content, and an inferior gluten and baking quality as compared with kernels from plants dusted with sulphur.[2]

Yellow berry of wheat has been described since 1904 as a physiogenic disease. No mention is made anywhere of the influence of rust attack in the enumeration of the causes of yellow berry. Studies revealed abnormal physical and chemical constants and inferior baking quality of diseased kernels. Heald[3, 4] reviewing the literature dealing with yellow berry summarizes the possible causes influencing the appearance of yellow berry as follows: (1) climatic factors operating upon the grain while in chaff, either during the last part of the ripening period or after cutting; (2) hereditary tendencies operating independent of environment; (3) disturbed nutrition, due to unfavorable water or soil relations.

The trial mentioned was made in a field under uniform cultivation and fertilization, sown with a pure selection of Florence wheat (Morocco origin). This is a mid-early vulgare variety bearing flinty kernels. It escapes rust attack when sown early but is very susceptible to stem rust when sown late. The dusted plants were mature and harvested ten days earlier than the nondusted ones.

Other factors being the same, the kernels affected with yellow spots in this trial may be ascribed to the influence of stem rust. Late sowing and subsequent late maturity influencing the appearance of yellow berry, as mentioned by Heald, may be considered as an indirect cause of the disease, particularly in wheat varieties escaping rust. It is suggested that decrease of protein content in affected kernels may be influenced by rust.

Since the application of sulphur, which controlled rust, also checked yellow berry, it may be assumed that the yellow berry is etiologically connected with the rust attack.

It may be supposed, therefore, that yellow berry in wheat bearing normally flinty kernels also may be controlled when sulphur is applied for the

[1] Minz, G. Control of rust in wheat by sulphur dusting. Hassadeh 25(3–4): 107. 1945. (Hebrew.)

[2] Plaut, M. Chemical analysis and baking test of flour from rusted wheat. Unpublished data.

[3] Heald, F. D. Manual of plant diseases. 953 pp. 1933.

[4] Heald, F. D. Introduction to plant pathology. 603 pp. 1943.

control of rusts in wheat.—GERSHON MINZ, Division of Plant Pathology, Agricultural Research Station, Rehovot, Palestine.

Physiologic Races of Yellow Rust of Raspberries in Western Washington.[1]—For many years yellow rust, *Phragmidium rubi-idaei* (DC.) Karst., has been an economic factor in the culture of red raspberries of western Washington. This disease has contributed to the decline of the Cuthbert and Marlboro varieties which are rapidly being replaced by the Washington and Tahoma varieties in this region. After the new Washington variety was introduced[2] it was observed to remain free from infection by yellow rust in the Puyallup Valley, even when grown close to rust-infected Cuthberts. These observations indicated that Washington might be immune or highly resistant to infection by *P. rubi-idaei.* However, in July, 1944, leaf specimens of Washington affected with yellow rust were sent to the writer by the Agricultural Extension Agent of Whatcom County, 125 miles north of the Puyallup Valley. Field observations showed rust to be generally present from a moderate to a severe degree in many commercial fields in Whatcom County where Washington was grown. Both uredial and telial stages were on the leaves of fruiting canes and current season's growth.

Three young plants, about two feet tall, of both Washington and Cuthbert were inoculated in the greenhouse at Puyallup, with a water suspension of urediospores from specimens of the rust brought in sealed bags from Whatcom County. Infection of both varieties was about the same (Fig. 1, A and B). The uredia were large and numerous on the leaves of all inoculated plants. A similar test was made with urediospores collected from the Marlboro and Cuthbert varieties grown in the Puyallup Valley. The Cuthbert plants were severely infected, but those of Washington appeared to be resistant (Fig. 1, C and D). Uredia, surrounded by more or less chlorotic areas, were present on the leaves of the latter variety but they were exceedingly small and never fully developed in comparison to those on the Cuthbert leaves. These tests were repeated in the greenhouse on six different occasions during the winter of 1944, with similar results. In two subsequent experiments the Tahoma variety was inoculated with the rust from both the Puyallup Valley and Whatcom County but no sori were observed on the inoculated leaves. Cuthberts serving as a check were heavily infected.

In raspberry fields in Whatcom County inspected during the summer of 1944 and 1945 there was no rust on Lloyd George or Newburgh varieties grown adjacent to affected Washington raspberries. In the Puyallup Valley the Cuthbert and Marlboro varieties were affected but only an occasional sorus was found on Washington. In instances where Cuthbert and Washington plants were grown in adjacent rows, or where Washington was interplanted in Cuthbert rows, Cuthbert was infected with rust, while no sori were observed on Washington. No rust infections have been observed on

[1] Published as Scientific Paper No. 656, College of Agriculture and Agricultural Experiment Stations, State College of Washington.

[2] Schwartze, C. D. The Washington and Tahoma red raspberries. Wash. Agr. Exp. Stat. Pop. Bull. No. 153. 1938.

Tahoma plants. Thus far Washington has been found affected with rust as far south as Snohomish County, but no serious outbreaks of the disease have been seen or reported on this variety southward to the Columbia River. On the other hand, Cuthbert and Marlboro, of which there remain only a few fields, are affected to some extent each year in this area.

The results of these experiments and observations suggest the likelihood that there are two distinct physiologic races of *Phragmidium rubi-idaei* in western Washington. Both Cuthbert and Washington raspberries are susceptible to the rust present on the latter variety in Whatcom County, while

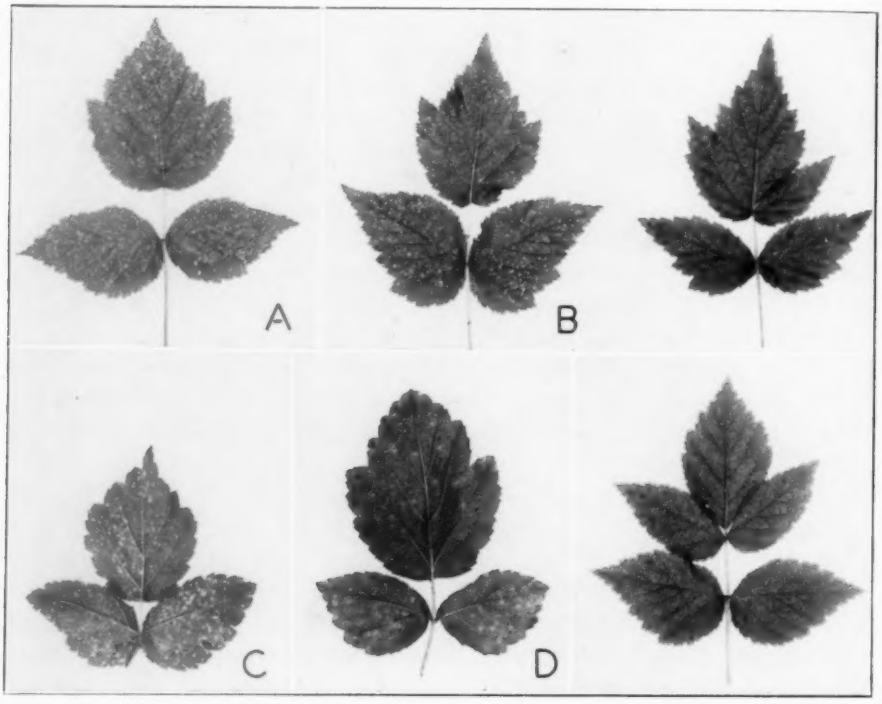

FIG. 1. A, B. Washington and Cuthbert raspberry leaves, respectively, with sori of western yellow rust after inoculation with rust collected from Washington variety in Whatcom County. Healthy Cuthbert leaf at right. C, D. Cuthbert and Washington leaves inoculated with rust collected from Cuthbert and Marlboro raspberries in Puyallup Valley. Note the scattered undeveloped sori on the Washington variety, D. Healthy Washington leaf at right.

Washington is resistant to the race collected from Marlboro and Cuthbert in the Puyallup Valley. In this case it seems unlikely that climatic factors might determine to such a large extent the development of the disease on different varieties, as has been referred to by Zeller.[3] He found that in Oregon the variety Ranere was more resistant to *P. rubi-idaei* than Cuthbert, but that the reverse is true in coastal regions of California.—FOLKE JOHNSON, Washington Agricultural Experiment Stations, Western Washington Experiment Station, Puyallup, Washington.

[3] Zeller, S. M., and W. T. Lund. Yellow rust of Rubus. Phytopath. 24: 257–265. 1934.

The Relation of Stomatal Behavior at the Time of Inoculation to the Severity of Infection of Soybeans by Xanthomonas phaseoli var. sojense (Hedges) (Starr) Burk.[1]—Difficulty in obtaining consistently good infection with bacterial leaf spots of field-grown crops has been a common experience. The testing of varieties for disease resistance requires reliable methods in order to be certain of the interpretation of the results. Stomatal behavior has been shown by Diachun[2] to be of importance in the infection of tobacco leaves by bacteria. Inoculation experiments were conducted in 1945 to evaluate this factor in the infection of soybeans in the field with the bacterial pustule disease caused by *Xanthomonas phaseoli* var. *sojense* (Hedges) (Starr) Burk. The experiments were performed at Columbia, Missouri, and Urbana, Illinois.

Different plots of the soybean varieties Lincoln and Chief were inoculated at two-hour intervals throughout one day in each of the tests. The inoculation started at 3 a.m. Central Standard Time when the stomata were practically closed and continued until 9 p.m. when the stomata were again practically closed. Strips of the lower leaf epidermis were placed into 100 per cent ethyl alcohol at the time of each inoculation and later the average width of the stomatal openings was determined. At Urbana, the light intensity was measured at the time of each inoculation. Precautions were taken to provide uniform inoculum throughout the day. The inoculum was applied with a power sprayer, which maintained approximately 150 pounds pressure, with the nozzle adjusted to deliver a stream of water unbroken until within a few inches of the leaves where it broke up into large droplets similar to beating rain. In each of the three tests with Lincoln and Chief, four replications were arranged as randomized blocks. Disease notes were taken ten to fourteen days after inoculation. The severity of infection for a row was rated on an arbitrary scale of 0 to 10, no infection being indicated by 0, and heavy infection on all leaves being indicated by 10.

The results have shown that inoculation between 8 a.m. and 2 p.m. gives the greatest amount of infection (Fig. 1). A logical conclusion would be that the bacteria enter when the stomata are open. Considerable dew developed on the plants during the nights concerned in each test, and attempts were made to select days of normal sunshine. This was nearly accomplished at Urbana, but in the tests at Columbia, it was partly cloudy during part of the day. Although the effect of cloudiness on stomatal behavior was not marked, it may be reflected slightly in the difference in steepness of the curves in figure 1 for the two locations. At Columbia, where slight cloudiness existed, the effect of increase in light between 6 a.m. and 8 a.m. was

[1] A contribution from the U. S. Regional Soybean Laboratory, a cooperative organization participated in by the Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, and the Agricultural Experiment Stations of Alabama, Arkansas, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Nebraska, North Carolina, North Dakota, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Virginia, and Wisconsin. Missouri College of Agriculture Journal Series No. 990.

[2] Diachun, Stephen. Relation of stomata to infection of tobacco leaves by *Bacterium tabacum*. Phytopath. **30**: 263–272. 1940.

not as sharp as at Urbana. Watersoaking of the leaf tissue by the spray was apparent immediately after inoculation during the bright part of the day, but was inconspicuous after inoculation at other times.

The results of these tests indicate that stomatal behavior should be a prime factor in the timing of inoculation of soybeans. Varieties which appear to be resistant when inoculated at midday, however, should be further examined to be certain that they do not have a different diurnal cycle, thereby escaping inoculation at a time when they are vulnerable. The general tendency in the past has been to inoculate field plants in darker periods (*e.g.*, early in the morning) and without particular attention to the force of the inoculum hitting the leaves.

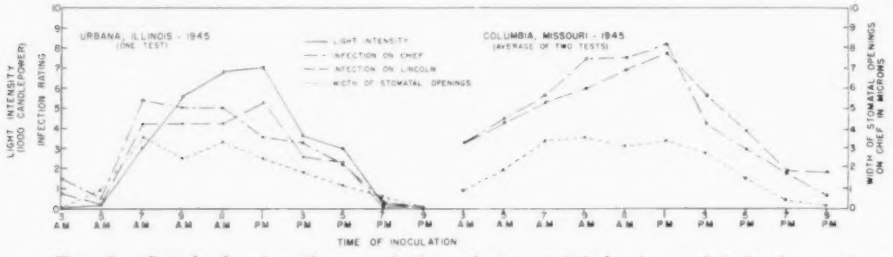

FIG. 1. Graph showing the correlation of stomatal behavior and infection ratings on Chief and Lincoln soybeans at Urbana, Illinois, and Columbia, Missouri, when inoculated by power spraying at different times of the day. (Central Standard Time.)

It is believed that the results reported here will be of considerable value in the development of an improved technique for inducing artificial epidemics in the field.—WILLIAM B. ALLINGTON, Associate Pathologist, U. S. Regional Soybean Laboratory, and CARL V. FEASTER, Cooperative Agent, Missouri Agricultural Experiment Station.

Reaction of Dodders to Stems of Other Dodders and to Their Own Stems.—While studying the relationship of the two dodders, *Cuscuta subinclusa* Dur. and Hilg. and *C. californica* Choisy, to certain host plants commonly used in the study of curly top and other virus diseases, the question arose as to what occurs when the stems of these dodders coil around each other. When these united stems are sectioned, stained, and examined under the microscope it becomes apparent that haustoria penetrate the encircled stems and connect with the vascular bundles in the same way they do in the case of sugar-beet petioles. *C. californica*, for example, will parasitize *C. subinclusa*, *C. campestris* Yunecker and *C. americana* L.

Figure 1, A, shows *Cuscuta californica* growing on *C. americana* which in turn is parasitic on *Nicotiana glauca*. The small amount of vegetative growth and the abundance of flowers indicate that *C. americana* is not a favorable host. Figure 1, B, is a transverse section of a stem of *C. californica* with a haustorium of *C. subinclusa* grown into it, with xylem vessels of the invading haustorium connecting with similar tissues of *C. californica*.

Further proof that this dodder definitely parasitizes the others was

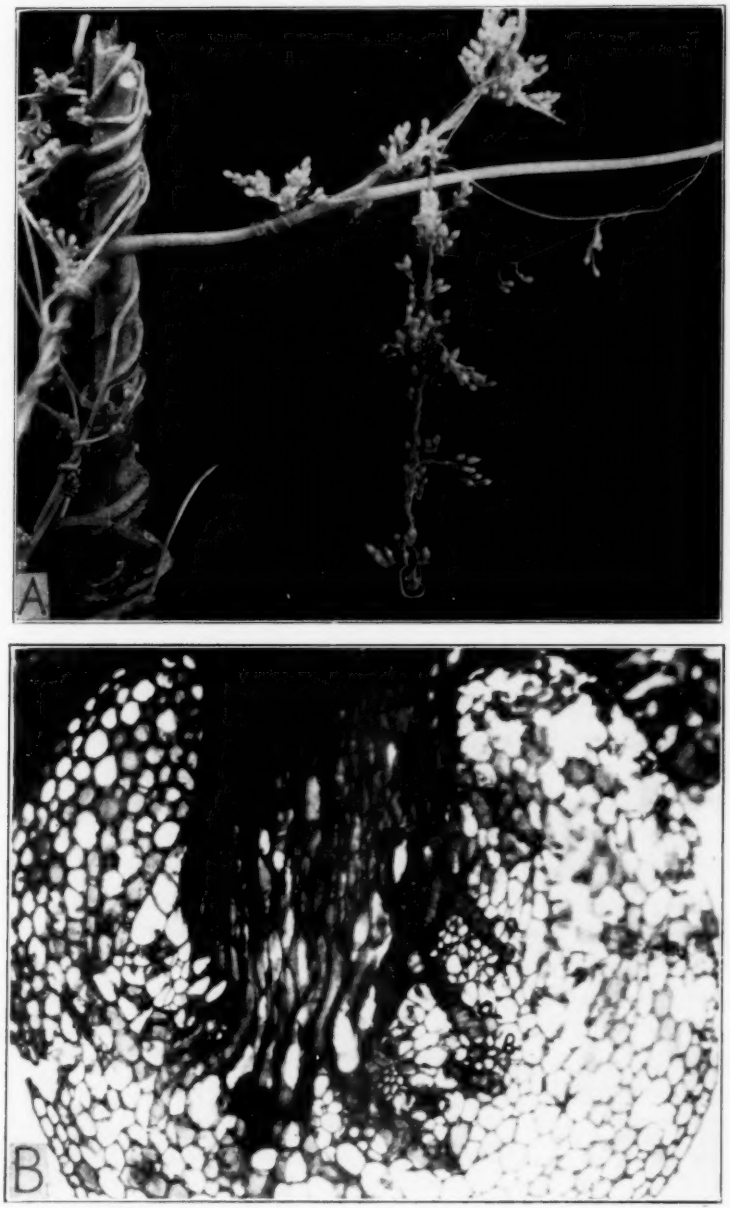

FIG. 1. A. *Cuscuta californica* growing on *C. americana*, parasitic on *Nicotiana glauca*. B. Transverse section of stem of *C. californica* invaded by haustorium of *C. subinclusa*, xylem elements of haustorium (a) connecting with similar elements of host (b).

obtained by the following tests. Rapidly growing stems of *C. californica* were taken from a tobacco plant and the basal ends put in a bottle of water. These stems were then allowed to establish themselves on the other species of dodders mentioned, which were growing on green host plants. Then these

stems were taken out of water and were forced to live on these dodder species as host plants.

The two dodders, *Cuscuta californica* and *C. subinclusa*, will turn back on their own stems and invade them with haustoria as they do on other species of dodder. There is no apparent harm done to the tissues of the dodders after being thus invaded. As in other host plants attacked by the dodders, the tissues are completely dissolved in the region occupied by the haustoria. Cells in contact with haustoria appear to be normal with no sign of disorganization. The haustorial hyphae contact phloem cells but do not invade them. They apparently receive nourishment from these host cells by diffusion. The xylem elements of the dodder intermingle with those of the host and seem to unite with them.—C. F. LACKEY, Division of Sugar Plant Investigations, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture, Riverside, California.

Infection Studies with Actinomyces scabies.[1]—The pathogenicity of *Actinomyces scabies* (Thaxt.) Güssow, the causal organism of potato scab, is not well understood although its parasitism was demonstrated over a half century ago by Thaxter. In recent infection studies, the organism killed radish seedlings growing in sterilized, artificially infested, highly calcareous peat soil. A localized necrosis of potato leaf blades and petioles has been obtained after spore suspensions were applied to wounded tissues.

Radish seedlings have been killed by the scab organism under controlled conditions in the laboratory. Isolates of *Actinomyces scabies* obtained from scab lesions on potato and red beet and known to be extremely virulent to potato were used throughout. Seeds which had been surface disinfected and germinated on 2 per cent water agar were placed in large, Pyrex test tubes containing sterilized peat soil which had been artificially infested with pure cultures of the scab organism. The first evidence of infection was on root tissue which became water-soaked with only slight discoloration. As necrosis developed, the tissues became dark brown. Aerial symptoms, developing first on the cotyledon, consisted of a wilting of the terminal portion of the leaf accompanied by general chlorosis and followed by necrosis of the entire lamina. The hypocotyl remained erect and apparently unaffected until after the terminal leaves were dead. Radish plants lived only 2 to 3 weeks in soil infested with *A. scabies*, whereas control plants growing in sterilized, noninfested soil were apparently free from disease and remained thus until the tests were terminated approximately one week later. Seedlings of radish grown in pots containing soil infested with the scab organism were noticeably stunted. Preliminary tests with cucumber, pepper, turnip, and spinach have indicated that *A. scabies* is sufficiently pathogenic to these plants to cause stunting and premature death. KenKnight[2] has made a detailed sur-

[1] Journal paper number J–1325 of the Iowa Agricultural Experiment Station, Ames, Iowa, Project 816.

[2] KenKnight, Glenn. Studies on soil actinomycetes in relation to potato scab and its control. Mich. Agr. Exp. Stat. Tech. Bull. 178. 1941.

vey of the literature concerning the development of *A. scabies* on the roots of various vegetables and weeds. He reported chiefly the production of localized, corky, scab-like lesions typical of those found on the tubers of the potato.

In our experiments, superficial, scale-like, necrotic areas, that were light gray to tan, were induced on Red Warba potato foliage by rubbing a spore suspension of the scab organism onto the leaves with the finger. Water-soaked spots which later dried and turned brown first appeared on the leaf blade and its veins. These necrotic areas did not enlarge after removal of the plants from the moist chamber 3 to 4 days after inoculation. Leaves of control plants rubbed with water in a similar manner, although evidencing some mechanical injury, did not become necrotic. Water-soaking the leaf tissues with a jet of spore suspension ejected from a hypodermic syringe onto the under surface of the leaf also resulted in necrotic lesions. When the plants were removed from the moist chamber, the water-soaked areas of plants treated with a spore suspension had a dark metallic luster, whereas the control leaves, treated with sterile water in a similar manner, were water-soaked and green. The affected tissues of the inoculated leaves soon became necrotic: the water-soaked areas of the control leaves recovered and no necrosis occurred. Necrotic areas of the inoculated leaves were brown to tan and apparently localized at the bases of trichomes. Affected areas did not noticeably enlarge after removal from the moist chamber. In general reactions were more severe on young leaves that were not completely expanded at the time of inoculation. In these preliminary trials, free-hand sections were not suitable for demonstrating actinomycetous filaments within affected tissues. Lutman[3] recently reported actinomycetous strands in apparently healthy leaves of potatoes.

Leaves situated at the soil line on Cobbler potato plants grown in artificially infested, peat soil have had a superficial necrosis similar to that described on leaves treated with suspensions of *Actinomyces scabies*. In a few instances necrosis was observed extending some distance into the petiole. The filaments of *A. scabies* were demonstrated in the intracellular spaces of such petioles by staining free-hand sections with Gentian violet.

Attempts to induce a reaction by atomizing spore suspensions on uninjured potato-leaf surfaces have not been successful.—W. J. HOOKER and G. C. KENT, Botany and Plant Pathology Section, Iowa Agricultural Experiment Station, Ames, Iowa.

Late Blight of Tomatoes in East Texas at Transplanting Time.—Tomato plants with late blight (caused by *Phytophthora infestans* (Mont.) de Bary) were found[1] near Jacksonville, Texas, in April, 1945. The late-blight symptoms appeared only on plants that had been brought from the Lower Rio

[3] Lutman, B. F. Actinomycetes in various parts of the potato and other plants. Vt. Agr. Exp. Stat. Bull. 522. 1945.

[1] Altstatt, G. E. Tomato late blight in East Texas. U. S. Dept. Agr. Plant Dis. Rptr. 29: 344–345. 1945.

Grande Valley, or on locally grown plants that were near the fields where these imported plants were set. The plants were shipped in March from the Lower Valley where late blight was severe on tomatoes and potatoes,[2] and where the disease has been more or less destructive each year beginning

FIG. 1. Tomato plants with late-blight symptoms. (A, B, C photographed at Jacksonville, Texas, on April 15, 1945. A, B: Plants from Lower Rio Grande Valley of Texas. C, D: plants from cold frame.) A. Tomato stem that was typically twisted and broken by a late-blight canker. B. Tomato stem with a longitudinal crack in a late-blight canker; also a cross section through the hollow canker. C. *Phytophthora infestans* killed the leaves, grew into the stem, and caused light brown cankers in cold-frame plants. D. New growth on a tomato stem, the top of which had been killed earlier by late blight; photographed on May 25, 1945.

[2] Altstatt, G. E. Late blight of potatoes and tomatoes in the lower Rio Grande Valley of Texas. U. S. Dept. Agr. Plant Dis. Rptr. 29: 233–234. 1945.

with an epiphytotic[3] in 1931. Earlier descriptions of tomato late blight were by Kern and Orton[4] and by Giddings and Berg.[5]

The largest loss from late blight occurred on a farm near Jacksonville where nearly 17 acres were set with young tomato plants from the Lower Valley. On April 15 most of the plants were dead. Typical symptoms of late blight and spores of the causal fungus were found on the remaining plants. Plants dying early had been reset 3 times with locally grown plants, and they also had died from late blight. Late blight in the stems caused prominent cracking, shriveling, twisting, and hollowness of the cankered areas (Fig. 1, A, B). Many of the tomato tops were broken over at the canker. The Phytophthora spores evidently had been carried by wind from the blighted plants in the field to tomato seedlings in a nearby cold frame. By April 15, late blight had injured or killed the tops of more than 10,000 plants in this cold frame, giving the seedlings a brown, scorched appearance (Fig. 1, C). When the cold frame was examined again on May 25, some of the plants were still alive and new tops had developed from branches below the cankers after the spread of the late-blight pathogen had been arrested by warm, dry weather (Fig. 1, D). On another farm, a grower had "heeled-in" Lower-Valley tomato plants beside a hot bed. All of the seedlings in the hot bed and nearly all of the Lower-Valley plants that were set in the field were killed by the late-blight fungus.

These observations indicate that *Phytophthora infestans* may be transmitted from one region to another through movement of infected tomato plants, and under favorable weather conditions an epiphytotic may occur in the newly infested area.—P. A. YOUNG, Tomato Disease Laboratory, Texas Agricultural Experiment Station, Jacksonville, Texas.

The Eradicant Action of a Fungicide on Colletotrichum lilii in Lily Bulbs.—Preliminary studies by Plakidas[1] on the control of black scale of the Easter Lily (*Lilium longiflorum* Thumb. var. *eximium*) caused by *Colletotrichum lilii* Plak. by treating diseased bulbs with fungicidal dips or dusts indicated that mercuric chloride, borax, basic copper sulphate, calcium hypochlorite, and brilliant green were ineffective. In most cases the treatments also caused considerable injury. Continuing this work, tests have been made with several of the new organic fungicides. The results obtained with one of these materials were of sufficient promise to justify a preliminary report.

A method of rapidly evaluating the effectiveness of the fungicides in the laboratory was devised. Scales bearing lesions were removed from diseased bulbs and treated, after which they were placed in sterile water for 24 hours.

[3] Taubenhaus, J. J., and W. N. Ezekiel. Late blight of potatoes and tomatoes. Texas Agr. Exp. Stat. Circ. 60. 1931.

[4] Kern, F. D., and C. R. Orton. Phytophthora infestans on tomato. Phytopath. 6: 284–287. 1916.

[5] Giddings, N. J., and Anthony Berg. A comparison of the late blights of tomato and potato. Phytopath. 9: 209–210. 1919.

[1] Plakidas, A. G. Black scale: A disease of Easter Lily bulbs. Phytopath. 34: 556–571. 1944.

They were then soaked for 4 to 5 minutes in a saturated solution of calcium hypochlorite for surface sterilization and plated on potato-dextrose agar. In check tests with scales immersed in tap water for 24–48 hours, fungus growth occurred from all scales, with *Colletotrichum lilii* constituting 50 to 75 per cent of the fungi present (Fig. 1). By using this method, a number of organic materials were eliminated as ineffective. Two materials, how-

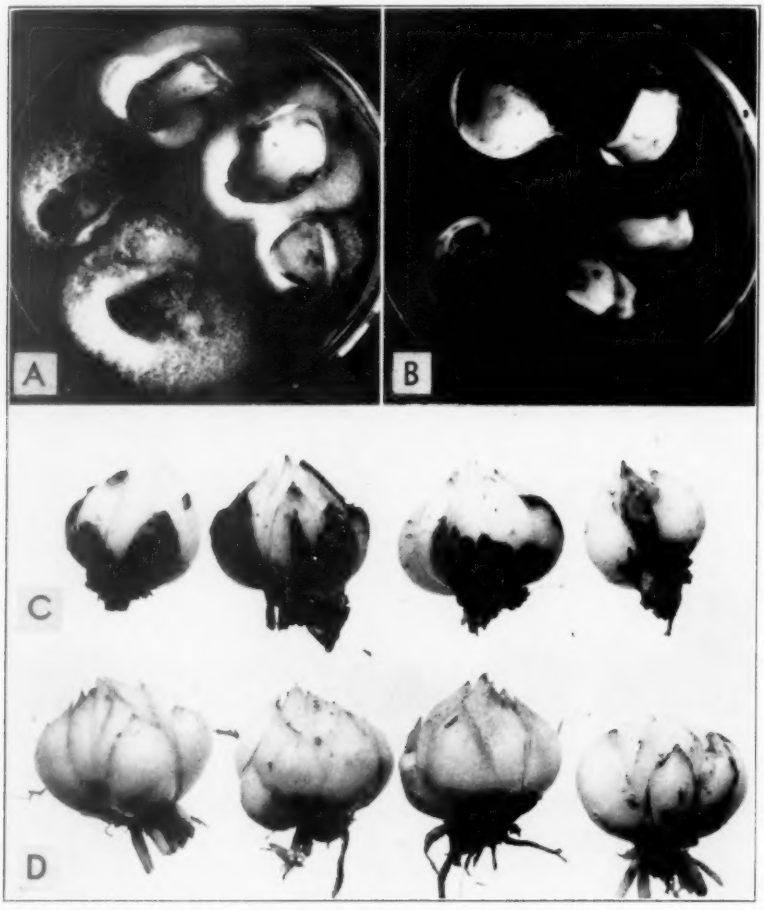

FIG. 1. Effect of Puratized N5X and N5E on the survival of *Colletotrichum lilii* in lily scales and bulbs. A. Nontreated scales on potato-dextrose agar, showing fungus growth. B. Scales treated with Puratized N5E, 1–2000, for 48 hours, on potato-dextrose agar, no fungus growth. C. Nontreated infected lily bulbs after 7½ months' growth in greenhouse. D. Lily bulbs treated with Puratized N5X, 1–2000, for 48 hours and grown in greenhouse for 7½ months.

ever, Puratized N5X and its improved form N5E (10 per cent phenyl mercuri triethanol ammonium lactate) at concentrations of 1–500 to 1–4000 where the treatment time was 24–48 hours, proved effective in killing the fungus in the scales. Reducing the treatment time to six hours failed to destroy the fungus even at concentrations of 1–250, indicating that the duration of the treatment was more important than the concentration of the fungicide.

These tests with Puratized N5X in the laboratory were followed by greenhouse tests with diseased whole bulbs. Representative results from these tests are given in table 1. Nontreated and treated bulbs from this test are shown in figure 1, C and D.

As in the laboratory experiments the effectiveness of the treatment was very much reduced when the treatment time was less than 24 hours regardless of concentration. In no case was injury to the bulbs or plants observed except where the treatment was for 24 hours or more at concentrations of 1–500 or greater. While emergence was reduced at these high concentrations, growth of the plants which emerged was not apparently affected.

In a field experiment in the 1944–45 season five lots, totaling 8 bushels, of heavily infected bulbs were treated with Puratized N5X, using different combinations of time of treatment and concentration of the fungicide. Be-

TABLE 1.—*The effect of treatment with Puratized N5X on the development of black scale on infected lily bulbs in pot experiments. Bulbs examined 7½ months after planting.*

Treatment	Concentration	Time	No. bulbs clean	No. diseased bulbs in classes[a]			Disease index[b]
				1	2	3	
Puratized N5X	1–1000	24 hr.	19	1	0	0	1.7
Do	do	48 hr.	15	1	0	0	2.1
Do	1–2000	24 hr.	10	0	0	0	0.0
Do	do	48 hr.	21	1	0	0	1.5
Do	1–1000	6 hr.	12	2	1	4	28.7
Do	1– 500	do	16	2	3	2	20.3
Check	.....	.....	3	4	2	9	64.8

[a] 1 = mildly diseased; 2 = moderately diseased; 3 = severely diseased.

[b] Clean, mild, moderately, and severely diseased bulbs were given numerical values of 0, 33.3, 66.6, and 100, respectively. The disease index for any given treatment was obtained by summing the products of the numbers of bulbs in each class and the numerical values of the classes and dividing by the total number of bulbs in the treatment.

cause the planting was in a quarantine area, it was not feasible to include an untreated control. However, the trend of disease development in lots receiving the different treatments corroborated the laboratory and greenhouse results. At concentrations of 1–1000 and 1–2000 of Puratized N5X for 48 hours the disease indices were 3.1 and 4.5, and the actual percentages of diseased bulbs were 5.7 and 8.7, respectively. At a concentration of 1–4000 for 24 hours, 28 per cent of the bulbs were diseased and the disease index was 15.2. In the field as in the greenhouse there was no evidence of injury.

In September and October, 1945, extensive plantings were made with bulbs treated with Puratized N5E under a wide range of conditions. While most of the bulbs were treated for 48 hours with a 1–2000 solution, in more limited treatments the concentration and the length of treatment were varied. Approximately 2,000 bushels of bulbs were treated, and by January, 1946, satisfactory stands were present in all cases. This indicated that this material may be used in the field with safety.—F. J. LEBEAU, Louisiana Agricultural Experiment Station, Baton Rouge, Louisiana.

ABSTRACTS OF PAPERS ACCEPTED FOR PRESENTATION AT THE THIRTY-SEVENTH ANNUAL MEETING OF THE SOCIETY, ST. LOUIS, MISSOURI, MARCH 27 TO 30, 1946

Fungi Causing Diseases of Sugar-beet Seedlings in Montana. AFANASIEV, M. M. Numerous isolations were made from diseased sugar-beet seedlings grown in the field and in the greenhouse. Isolates include representatives of the following genera: *Phoma, Fusarium, Macrosporium, Rhizoctonia, Pythium,* and *Aphanomyces.* Beet seedlings in either chloropicrin-disinfected or steam-sterilized soil in the greenhouse were inoculated with many of these organisms. *Fusarium, Macrosporium,* and *Rhizoctonia* were only slightly pathogenic, *Phoma* and *Pythium* were moderately so, and *Aphanomyces* was the most pathogenic on sugar-beet seedlings. The symptoms produced by *Aphanomyces* on sugar beets grown in the greenhouse resemble those of the diseased seedlings in the field. Seedling diseases of sugar beets, from the standpoint of the organisms involved, are complex, and it is believed that in Montana *Aphanomyces* is more important as a pathogen than is any of the other fungi mentioned. Some of the fungi studied are only weak parasites and possibly act as secondary invaders.

A Bean Virosis of Importance in Montana. AFANASIEV, M. M., and H. E. MORRIS. For a number of years a virosis was observed on Great Northern bean, a variety resistant to *bean virus 1.* This virus closely resembles *bean virus 2.* Bean leaves are mottled, distorted, and crinkled, and older plants become rugose, dwarf, and spindly. Plants grow slowly, bloom late, and yield poorly. The virus is not transmitted through the seed. Infection resulted when the infectious plant juices were inoculated into Great Northern beans U.I. 15, U.I. 59, Mont. 1; Red Kidney; Pinto; Ideal Market; and on white and yellow sweet clover. Results were negative when red, Alsike, Ladino, and Dutch White clovers and alfalfa were inoculated. Although symptoms varied, all bean varieties were equally susceptible except for Great Northern Montana 1 which was somewhat less susceptible. Inoculated leaves of white and yellow sweet clovers had a chlorotic mottling. Bean varieties became infected when inoculated with juice from field-grown white and yellow sweet clovers and Red Kidney beans having symptoms similar to inoculated plants grown in the greenhouse. The sweet clovers or some other leguminous plants probably may be the source of infection on beans. The virus was inactivated in a dilution greater than 1–100; by heating for 10 minutes at 60° C.; and by aging in vitro for 18 hours or longer.

Brown Stem Rot of Soybean Caused by an Unidentified Fungus. ALLINGTON, WILLIAM B. This disease appeared in a few fields in Central Illinois in the fall of 1944, and in 1945 it occurred in severe epidemic form in Central Indiana, Illinois, and Iowa. The damage in Central Illinois was extensive, reaching 10 per cent in some counties. Complete loss of yield occurred in some fields. Symptoms consist of browning of the pith and xylem of the stem, starting at or below the soil level and progressing slowly upward with only slight external symptoms in evidence in the form of occasional blighting of lower leaves. Then with unusual rapidity the leaves in the tops of the plants develop an interveinal chlorosis that is quickly followed by necrosis. In advanced stages the outside of the stem appears brown and the plants lodge badly because of extensive internal rotting. Temperatures must be low for disease development. The fungus appears to be soil-borne and generally present in the Midwest. The dense, putty-colored, nonfruiting mycelium grows slowly on all media tested. Isolation and artificial inoculation are readily made by standard methods. A few fields have indicated that continuous cropping to soybeans may increase the disease damage.

Effect of Growth Substances on Glomerella cingulata. ANDES, J. O. Fifteen growth-promoting substances were tested on 4 monosporic lines of the organism by addition to a mineral-salts–glucose medium containing purified agar. Colonies were grown comparatively in Petri plates. Growth, as measured by colony diameter, increased in all lines when choline chloride was added. One line responded to the addition of niacin and another to the addition of thiamine.

A Chromogenic Line of Glomerella cingulata Derived from an Ascospore. ANDES, J. O. Six ascospores isolated from a single ascus produced 5 typical plus colonies and 1 red colony. The red culture produced conidia abundantly but never formed perithecia, either alone or when mated with plus or minus lines. It appears to be identical with another chromogenic line that was isolated from an apple by M. C. Goldsworthy.

Manganese Toxicity, a Factor in the Cause of Internal Bark Necrosis (Apple Measles). BERG, ANTHONY, and GENEVIEVE CLULO. Investigations for 6 years showed that the tissues of apple trees affected with this disease usually contained abnormal amounts of manganese. Accordingly, the rôle of manganese was determined in a series of greenhouse experiments. When Red Delicious trees were grown in soil which had been taken from orchards where the disease was severe and to which manganese was added both the number of plants affected and the severity of the disease increased. Rome Beauty, a variety normally not subject to the disease, when grown in similar soil and similarly treated did not become affected, although the tissues took up large amounts of manganese. Red Delicious trees grown in soil obtained from locations where the disease did not occur became diseased when manganese was added. The controls in this soil did not contract the disease. Red Delicious trees grown in sand culture to which varying amounts of manganese were added also became diseased at the higher concentrations of manganese. In all cases the disease appeared in late summer or early fall and developed with great rapidity after the first signs became visible. Preliminary experiments indicate that incorporation of lime in the soil inhibits absorption of manganese and tends to prevent this disease.

Diseases of Teosinte in Mexico. BORLAUG, N. E. Two smuts have been collected on teosinte (*Euchlaena mexicana* S.) in the vicinity of Amecameca, Mexico. One was identified as *Ustilago Kellermanii* C., while the second has been tentatively classified as *Sorosporium*. Both staminate and pistillate inflorescences and their supporting tissues are affected by *Sorosporium*, this smut being distinctly different from *U. Kellermanii*. Although a large number of collections of teosinte have been made in various parts of Mexico during the past year, smuts have been found only in the one area. By far the most common disease of teosinte throughout its range in Mexico is leaf rust (*Puccinia sorghi*) which has been collected from widely separated geographic areas.

Puccinia sorghi on Corn in Mexico. BORLAUG, N. E. Recent studies have demonstrated the existence of corn rust throughout Mexico. However, for many years there has been considerable selection for rust resistance on a regional basis. In 1944–1945 collections of lines and varieties of corn from Mexico, the United States, Cuba, Venezuela, Hawaii, and Guatemala were grown in field tests at Chapingo, Mexico. Tremendous differences were observed in their reactions to races of *Puccinia sorghi* in that area. Reaction varied from a high degree of resistance to complete susceptibility and early death. In general, varieties native to the area in which tests were made were resistant; lowland corns were highly susceptible and many hybrids, inbreds, and varieties from other countries were completely susceptible. The distribution of races of *Puccinia sorghi* in Mexico is being studied along with the significance of the 3 species of *Oxalis* which rust heavily each year.

Tubercularia Canker and Dieback of Ulmus pumila L. CARTER, J. C. In August, 1939, branch and trunk cankers were observed on several trees 4 to 10 feet tall in a commercial nursery planting of Siberian elm (*Ulmus pumila* L.). Single-spore isolations were made from black sporodochia that had developed in the cankerous bark. The fungus isolated was a species of *Tubercularia*, apparently undescribed. Seven trunk and 18 branch inoculations were made on 21 Siberian elms on April 6, 1940. Infection developed from 6 of the trunk inoculations and 17 of the branch inoculations, and subsequently cankers were produced. In general, infection became evident within 10 days and sporodochia became visible in about 20 days. Cankers on trunks and branches continued to enlarge until mid-June, at which time callus tissues began to develop at their margins. By late August many of the cankers were covered with callus. Cankers produced by both inoculations and natural infections failed to enlarge in succeeding years. Branches which had been inoculated gradually died downward from the point of inoculation, usually to distances of 4 to 8 inches by mid-June.

A New Race of Cercospora oryzae on Rice. CHILTON, ST. JOHN P., and E. C. TULLIS. Previous to 1944 the rice variety Rexoro was resistant to the various races of *Cercospora oryzae* known to occur in Louisiana and Texas. In 1944, this variety was found with susceptible-type lesions. In 1945, the disease had spread over nearly all the Louisiana and Texas rice-growing areas. In inoculation tests, the varieties Blue Rose, Blue Rose 41, Caloro, and Fortuna, which are used to separate the 4 known races of *C. oryzae*, were resistant to cultures of this new race from Louisiana and Texas. Texas Patna and Bluebonnet, two new varieties recently released, for which Rexoro was one of the parents, were both susceptible to the new race. All F_2 generations in crosses between resistant varieties and Rexoro segregated in a 3 : 1 ratio, with 3 resistant and 1 susceptible. (Louisiana Agricultural Experiment Station and U. S. Department of Agriculture.)

Genetic Variation in Gibberella zeae in Relation to Adaptation. CHRISTENSEN, J. J. As a result of genetic variation a monoconidial isolate of *Gibberella zeae* appeared to develop increased tolerance to malachite green, mercuric chloride, and ethyl mercury phosphate. When grown on potato-dextrose agar containing various concentrations of these toxic substances the fungus produced many distinct variants differing from their parent in cultural characters, physiology, pathogenicity, and morphology. On malachite-green agar some variants grew more than 100 times faster than their parent, while others grew at slower rates. These differences have persisted for many cultural generations. In the absence of mutation, there was no correlation between the number of generations a line had grown on a toxic medium and its ability to grow on it. However, the source of inoculum had a decided effect on the ability of certain variants to begin growth on a toxic medium. Variant 1–2 failed to grow readily on malachite-green agar when the transfer was made from Smith-Humfeld agar but grew perfectly well when taken from potato-dextrose agar. A mixture of several distinct variants was grown for several cultural generations on potato-dextrose agar; then, when grown on toxic media, the component lines assorted themselves so that they could readily be recognized.

The Effect of Shading Techniques on Transmission of Tobacco-mosaic Virus through Dodder. COCHRAN, G. W. In transmission experiments, virus-free dodder, *Cuscuta campestris*, established on healthy potted tomato plants was passed through paper barriers and connected to tomato plants infected with tobacco-mosaic virus. In one experiment, 75 per cent transmission occurred when healthy plants were starved by holding in darkness, with all growing points removed from the connecting dodder. No transmission of virus occurred to an equal number of unstarved healthy plants connected by unpruned dodder. In another experiment, all dodder growing points were removed after connections were established. All diseased plants and half of the healthy plants were held under continuous light. The remainder of the healthy plants were starved of carbohydrates by bagging. Dodder connections were maintained for 2 weeks. Virus was transmitted to 83 per cent of the carbohydrate-starved plants and to only 3 per cent of the unstarved plants. The removal of all dodder growing points resulted in a channeling of carbohydrates and virus directly across the dodder stem from plant to plant. The direction of carbohydrate movement through this dodder channel was apparently determined by the carbohydrate gradient. A high carbohydrate level in diseased plants and a very low level in healthy plants favored virus transmission.

Ring Spot, A Common Contaminant of Stone Fruit-Virus Cultures. COCHRAN, L. C. In host range studies with stone fruit viruses, if we infect a suspect host of a different species with inoculum from a mother plant and, in turn, reproduce similar symptoms on the mother plant species by transfer from the infected suspect host, we conclude the symptoms produced in the suspect host to represent those of the virus causing the disease in the mother plant. This technique is not sufficient to show that the mother plant was not carrying two viruses, one producing symptoms in the original or mother plant and existing latent or obscured in the second or suspect host, whereas the other existing latent in the mother plant is responsible for symptoms in the suspect host, both of which were transmitted in each transfer. The ring-spot virus has been found widely existent in both cultivated and wild prunus species in nature. This virus is a complex with many forms, most of which produce symptoms only in the early stages of infection and some of which infect certain hosts without symptoms. Source material of other viruses and commercial nursery stock has commonly been found carrying the ring-spot virus without visual symptoms. Conclusions drawn from work with contaminated stock will result in confusion in the literature.

Interaction of Some Forms of the Peach-mosaic Virus. COCHRAN, L. C., and JOHN L. RUE. Extended studies have demonstrated the existence of a multiplicity of forms of the peach-mosaic virus capable of producing a symptom gradient on Hale peach ranging from a severe effect to one so mild that diagnosis is doubtful. Early work indicated that forms producing mild effects commonly arise in trees affected with severe forms and can be obtained from mildly affected sport-like branches. If trees developed from these sport-like branches were reinoculated from the "severe" portion of the mother tree, no increase in severity of symptoms resulted. Bodine found that mild forms protect against severe forms from the same locality in Colorado. In many combinations the authors have obtained conflicting results. A mild form arising in Texas inhibited symptom production by a severe form from Texas but failed to interfere with a severe form from Arizona. Similarly an Arizona mild form protected against the Arizona severe form but failed to inhibit the Texas severe form. In other combinations mild forms variously moderated the symptoms of severe forms as compared with checks. It thus appears that the peach-mosaic virus is a complex of variously related forms which compete in peach.

A Wilt and Root Rot of Asparagus officinalis L. var. altilis L. COHEN, SYLVAN IRVING. *Fusarium oxysporum f. asparagi* causes a root rot and vascular wilt in asparagus in the United States which is distinct from a foot rot in Germany caused by *F. culmorum*. It may affect 25 to 50 per cent of a planting, producing yellowing, stunting, and wilting of the growing stalks. Vascular discoloration occurs within affected stems, roots, and crowns, and it is associated with reddish brown lesions and rotting. When nurseries are established in contaminated soils, a severe damping-off occurs in circular areas. Single-spore isolates of the fungus from Washington, California, and South Carolina proved to be morphologically and culturally indistinguishable and were equally pathogenic. A soil temperature of 28° C. and sandy soils favor the development of the disease. Because of the anatomy of asparagus, severe symptoms may appear one year and not the next, although the plant is still infected. No effective control measures are known. Observations of field plots reveal that fertilizers have no significant effect upon the disease. Twelve species and varieties of the genus *Asparagus* proved equally susceptible. What appears to be the same disease has been reported since 1908 as "stem rot," "dwarf asparagus," "stem canker," "root rot," and "wilt."

Plant Pathology in the U. S. Navy in Wartime. COOK, HAROLD T. Duties performed by the author while an officer in the U. S. Navy in the South and Central Pacific areas in World War II demonstrated that the training and experience of plant pathologists may be applied profitably to problems of production, procurement, and handling of food supplies for the Armed Forces and indicated that plant pathologists may be used efficiently in the Armed Forces in future wars. Duty in the South Pacific was to organize and direct inspection of fresh, canned, dehydrated, and quick-frozen fruits and vegetables obtained from New Zealand. This involved preparation of specifications, training and supervision of inspectors, and establishment of procedures and policies. Additional duties were to increase production and develop improved methods of harvesting, packing, and storing. Surveys were made of the availability of certain food supplies. A manual for cool storage and handling of fresh vegetables was prepared. Refrigerated shipments to the Forward Areas were studied and improved methods of loading and handling such cargoes were instituted. Assignment in the Central Pacific was to command a Naval Unit engaged in growing fresh vegetables on the islands. Production in those areas involved numerous cultural, disease, and insect problems.

Helminthosporium Foot Rot of Barley. DICKSON, J. G. In 1943 and 1944, barley yields were low throughout the North Central spring-barley area, where Wisconsin Barbless occupies most of the acreage. Late sowing and conditions favorable for attack by *Helminthosporium sativum* Pam., King, and Bakke were among the factors that apparently accounted for this barley failure. Temperature and moisture experiments in the greenhouse have demonstrated the importance of *H. sativum* foot rot and the relative susceptibility of Wisconsin Barbless in contrast to that of Oderbrucker. The inoculum used was a composite of *H. sativum* cultures isolated from barley kernels obtained through the area in the 2 years. Clean seed of both varieties was inoculated with a conidial suspension and sown in soil, after which the fungus growing on oat hulls was incorporated into the surface layer of the soil. The plants were grown in the greenhouse to the fully headed stage at 52° and at 70° F. in moderately dry and wet soils. Moisture was maintained by subirrigation. In both varieties, less seedling blight occurred at the lower temperature and in the drier soil than in the wet soil at the higher temperature. At 70° F, foot rot was severe in both the moderately dry and wet soil, Oderbrucker having 60 per cent healthy plants in contrast to 15 per cent in Wisconsin Barbless. At 52°, Oderbrucker had 91 per cent healthy plants and Wisconsin Barbless 81 per cent. (Wisconsin Agricultural Experiment Station and U. S. Department of Agriculture.)

Spread and Control of Oak Wilt. DIETZ, S. M. and JAMES W. BARRETT. Oak wilt has been found in Illinois, Iowa, Minnesota, Missouri, and Wisconsin. This disease, caused by *Chalara quercina* Henry and first recorded in Iowa in 1932, occurred throughout the State in 1944 and 1945, being most severe in the eastern part. It has been epiphytotic on *Quercus alba, Q. borealis maxima, Q. ellipsoidalis, Q. imbricaria, Q. macrocarpa,* and *Q. velutina*. Using Koch's postulates, the 13 species of oaks recorded as native to Iowa have been proven as hosts for *Chalara quercina*. The rate of spread, which occurred in concentric zones from the initial point of infection, varied with the season and the species of oak. Initial infection is in the crown of the tree and the fungus progressively infects leaves, stem, and roots. The fungus spreads more rapidly in red oak trees than in white or burr oak. The symptoms varied with the species of oak. The fungus rarely overwinters on red oak, usually on white and burr oak. It has been isolated repeatedly from dead twigs 6 months after infected trees were felled. For 2 years various sanitation methods have checked and sometimes controlled the spread of oak wilt.

Improvement of Ascorbic Acid Content in Yellows-resistant Cabbage. FOSTER, R. E., and J. C. WALKER. Individual plants of several standard or improved varieties of cabbage homozygous for the gene for type A resistance to yellows were crossed with individuals from a Wisconsin All Seasons line high in ascorbic acid content but containing only type B resistance to yellows. F_1 and F_2 progenies were studied to obtain individuals with high vitamin C content, desirable varietal type, and type A resistance to yellows. Ascorbic acid content was controlled by multiple factors. Breeding lines of cabbage varied in the number of factors controlling this character. Transgressive segregation toward increased vitamin C content was apparent in some of the F_2 progenies. By use of the individuals selected, there may be developed lines of several commercial varieties having a greatly increased ascorbic acid content as well as homozygous type A resistance to yellows.

Differences in Diploid Lines of Ustilago zeae. GATTANI, MOHAN LAL. Several diploid lines appeared in the progeny of cross 410, between the relatively stable haploid line $10A_4$ and the mutable haploid line $17D_4$. Seven diploid lines differed from the parents and from each other in the following characters: 1) appearance on nutrient media; 2) rate of growth and enzyme production; 3) adaptability to arsenic and malachite green; 4) ability to cause anthocyanin production on 4 selfed lines of corn; 5) pathogenicity on corn plants. One of the diploid lines, 410qq, intermediate between the parents in most cultural and physiologic characters, was mutable like the $17D_4$ parent. Numerous mutations were induced by growing 410qq on media containing lithium, arsenic, or uranium. Some of these mutants closely resembled the mutable haploid parental line $17D_4$ or its haploid mutants; moreover, some of the mutants of the diploid 410qq were haploid, as indicated by their inability to infect corn plants alone. When these mutants were paired with $10A_4$, however, normal infection resulted, thus indicating that dissociation of diploid line 410qq resulted in the production of haploid lines similar in many respects to $17D_4$, one of the original parents.

An Actinomycete Inducing Wood Necrosis and Gummosis in Citrus. GODFREY, G. H. An unidentified Actinomyces-like organism produces a distinctive type of plant disease—a wood necrosis and gummosis of citrus trees—which is the most serious citrus tree disease in the Lower Rio Grande Valley of Texas. The symptom is a meandering band of necrotic wood, well beneath the bark. It is light ochraceous buff to ochraceous buff (Ridgway), bordered in the region of advancing infection by a narrow band that is apricot orange to rufous. Where an advancing band grows outward to the cambium, that tissue is killed, the bark cracks, and gum exudation varies from slight to extreme. This is the prominent external symptom of the disease. Severely affected branches are killed, and after infection has spread well into the wood in the trunk, the entire tree dies. Histological studies show the organism, with very small but clearly defined hyphae and spores with dimensions within the range of bacteria, to be abundant in affected tissues. It clogs the xylem tubes and invades the cells in the medullary rays. Inoculations into healthy branches have consistently reproduced the disease. Progress has been made on control by (1) pruning off badly affected branches, (2) excavating affected wood and treating the exposed healthy wood with a penetrating disinfectant, (3) preventing new infections by avoiding wounding of the bark and by treating all pruning wounds.

Control of Decay in Citrus Fruits. GODFREY, G. H., and A. L. RYALL. In a six-year series of tests for Diplodia stem-end-rot control, chiefly on lemons in the Lower Rio Grande Valley, thirty materials were used. Most of them were unsatisfactory. Sodium ethyl mercurithiosalicylate (Merthiolate) throughout the series consistently gave nearly perfect control, and it was used throughout as a standard for comparison with other materials. In 21 tests in concentrations of 1 to 10 and 15 thousand it averaged 1.2 per cent decayed fruits with many of the tests giving perfect control, when checks averaged 27 per cent stem-end decay and ranged from 5.5 to 86 per cent. Phenylmercuri 2–2–2 nitrilotriethanol lactate (Puratized N5E) and Thiourea also gave good control. Sodium orthophenylphenate was less efficient and required thorough rinsing after treatment to avoid serious chemical injury. Saturated borax solution and 5 per cent sodium metaborate both gave fair control but had a tendency to cause dull fruit and sometimes early wilting and shrivelling. The treatments that were most effective in the control of Diplodia stem-end rot usually also reduced the blue and green molds (*Penicillium spp.*); but in occasional lots in mid-winter such decay was high in spite of chemical treatments. The use of diphenyl-impregnated tissue as fruit wraps reduced blue mold to a point well below that occurring after fruit-dip treatments alone. In a typical case following sodium metaborate dip, there was 46.4 per cent blue mold in plain wraps and 6.7 per cent in diphenyl wraps; following Merthiolate there was 29.4 per cent in plain and 7.8 per cent in diphenyl wraps; in the checks there was 56.7 per cent in plain and 10.7 per cent in diphenyl.

Species of Fusarium Isolated from Samples of Cereal Seed in Canada. GORDON, W. L. A total of 18 species, varieties, or forms of *Fusarium* representing 9 sections of the genus, were isolated and identified from 1579 surface-sterilized seed samples of wheat, 1152 of oats, and 1042 of barley produced in the 8 seed-inspection districts in Canada during 1939 through 1943. *Fusarium poae, F. sporotrichioides, F. avenaceum, F. equiseti, F. scirpi, F. scirpi* var. *acuminatum, F. culmorum, F. graminearum, F. sambucinum,* and *F. oxysporum* were isolated from samples of wheat, oats, and barley; *F. scirpi* var. *compactum* and *F. moniliforme* from wheat and oats; *F. sambucinum* form 1 and *F. solani* from oats and barley; *F. arthrosporioides* from wheat; *F. lateritium* from oats; *F. semitectum* var. *majus* and *F. equiseti* var. *bulatum* from barley. Fusaria occurred in a greater percentage of the samples of oats and barley than of wheat; and in a greater percentage of the samples obtained from Eastern than from Western districts. Only a small percentage of the seeds of the 3 crops harbored Fusaria, the highest proportion in any of the districts being 2.6 per cent of the seeds of wheat, 8.5 per cent of oats, and 7.1 per cent of barley.

Control of Fusarium Wilt of Tomato with Dithane. GOTTLIEB, DAVID, and J. W. HEUBERGER. Preliminary experiments with soils in pots in the greenhouse were made on the use of Dithane (disodium ethylene bisdithiocarbamate) to control the Fusarium wilt of tomatoes. Dithane was mixed with infested and noninfested sassafras loam soil at a rate approximating 100 lbs. per acre. The average emergence of tomato seedlings was 24.4 per cent greater in the treated soil than in the checks. In the same experiments, 95.3 per cent of the plants in nontreated infested soils wilted, but only 19.3 per cent wilted in those infested soils which contained Dithane. When seedlings were transplanted 3 months later to these experimental soils, 88.3 per cent of the plants wilted in the nontreated, infested soil and less than 1.0 per cent in the Dithane-treated, infested soil. This indicates that the fungicidal effect of the Dithane may last for some time with normal greenhouse watering. In noninfested soils the fungicidal treatment did not prevent or reduce the germination of tomato seeds, but seedlings were stunted when grown in treated soils.

Polymodal Dosage-Response Curve between Calcium-potassium Ratio and Potato Scab. GRIES, GEORGE A., JAMES G. HORSFALL, and H. G. M. JACOBSON. The literature on ecology of potato scab records disagreement as to relative importance of hydrogen, calcium, and potassium ions. Experiments have been made on 2 soil types in 2 years with calcium as sulphate and carbonate, and hydroxide and potassium as sulphate and chloride. The incidence of scab was measured by grading the tubers on the basis of percentage of area scabbed. The disease bore the expected relation to hydrogen ions, but when pH was constant, the curve for percentage of scab showed several modes of high scab separated by "valleys" of low scab as the applied Ca–K ratio increased in 3-fold units from 0.07 to 486. In that range there appeared to be about 3 peaks spaced about 9-fold apart. The curves matched well in both years if the experimental variables were held constant. Alteration of soil type or the cation, however, altered the position of the peaks and valleys. The basis for the polymodal curve seems to be that calcium and potassium act antagonistically in the production of potato scab. The degree to which they antagonize each other apparently depends on the relative amounts of each. The occurrence of polymodal curves is not uncommon in biological research where 2 antagonistic factors such as H and OH are varied simultaneously. The 2 factors need not be necessarily antagonistic so long as their effects do not alter at equal rates with dosage. (Purdue University Agricultural Experiment Station and Connecticut Agricultural Experiment Station.)

Burn-Blight of Jack and Red Pine Following Spittle Insect Injury. GRUENHAGEN, R. H., A. J. RIKER, and C. AUDREY RICHARDS. A serious disease, first brought to attention in 1941, has been killing jack and red pine progressively from top to bottom. In northeastern Wisconsin the damage now extends over 6000 acres on 64 areas in 9 counties. Evidence, which included completing Koch's postulates with 6 single-spore isolates, showed *Chiloncctria cucurbitula* (Curr.) Sacc. to be the causal agent. The disease usually followed injury by the Saratoga spittle insect (*Aphrophora saratogensis* Fitch), which carried the fungus and introduced it while making numerous feeding punctures in the twigs. This insect was active from early July through September. However, the fungus usually appeared to incubate over fall and winter and induced most rapid necrosis from April to mid-July. Although the fungus usually entered through spittle insect-feeding punctures, it was found developing from wounds caused by other agencies. Jack pine on a poor site, over a 14-month period, had over 100 times more disease than comparable trees on a good site. Severe top and branch pruning did not increase the incidence of disease on jack pine. The most promising immediate preventive seems to be control of the insect vector. (U. S. Department of Agriculture, Wisconsin Conservation Department, and Wisconsin Agricultural Experiment Station.)

A New Race of Ustilago avenae. HANSING, E. D., E. G. HEYNE, and T. R. STANTON. A collection of loose smut was made from Fultex oats in Kansas in 1944 and identified as a new race in 1945. It is characterized by the resistance of the smut testers, Black Mesdag, Large Hull-less, Red Rustproof, and Fulghum (0 to trace smut), and the susceptibility of Richland, Monarch Selection, Green Mountain, Joanette, Victoria, Canadian, and Monarch (49 to 95 per cent smut). Of new varieties of oats distributed during the last 7 years or now ready for distribution to growers, Bonda, Mindo, Neosho, and New Nortex were highly resistant, having no smutted panicles. Goldwin, Benton, Clinton, Marion, and Mission were moderately resistant (1 to 3 per cent smut), whereas, Osage, Ventura, and Forvic were intermediate in susceptibility (9 to 26 per cent smut). Boone, Vicland, Cedar, Tama, Florilee, Fultex, and Traveler, all Victoria-cross selections, were highly susceptible (74 to 96 per cent smut). Regarding other varieties tested, Markton, Brunker, Bond, and Navarro were highly resistant (0 to trace smut), whereas, Kanota, Fulton, Trojan, and Otoe were moderately resistant (1 to 6 per cent smut). Columbia was intermediate in susceptibility (22 per cent smut). Of hybrid oat selections in the Kansas Advanced Yield Test, the Cooperative Uniform Spring Sown Red Oat Test, and the Cooperative Uniform Oat Smut Nursery, 65 of 105 selections were resistant (0 to 1 per cent smut) to this race. (Kansas Agricultural Experiment Station and U. S. Department of Agriculture.)

Effect of Bunt on the Development of Seedling Blight and Foot Rot of Wheat. HANSON, E. W. Ceres and Ulka wheat plants from seed inoculated with a mixture of several races of *Tilletia foetida* and *T. caries* developed more seedling blight and foot rot than plants from seed not inoculated with bunt when grown in the field or in nonsterile field soil in the greenhouse at St. Paul, Minnesota, in 1945. All experiments were of split-plot design and included 8 replications. Seedling-blight infection ratings increased from an average of 12 per cent in noninoculated plots to 40 per cent in inoculated plots. Similarly, foot-rot infection ratings increased from 31 per cent in the checks to 72 per cent in the plots inoculated with bunt. The combined effect of bunt infection and seedling blight caused an average reduction in seedling vigor of 13 per cent, as indicated by green weight, and a reduction in seedling stand of 8 per cent, as compared with plots not inoculated with bunt. The average stand at maturity in plots having both bunt and foot rot was 16 per cent less than for plots having foot rot only. There was no significant effect of bunt on the average number of tillers per plant. (United States Department of Agriculture and Minnesota Agricultural Experiment Station.)

Effect of Fusarial Head Blight on the Development of Bunt of Wheat. HANSON, E. W. Fusarial head blight reduced the percentage of heads with bunt in 92 out of 110 hard red spring and durum wheats in preliminary experiments at St. Paul, Minnesota, in 1945. Duplicate series of the wheats were inoculated with a mixture of several races of *Tilletia foetida* and *T. caries* and sown in adjacent field plots. Both plots were treated identically until the wheats reached the heading stage when one plot was sprayed almost every evening with a spore suspension of *Gibberella zeae* and *Fusarium spp.* until an epidemic of head blight developed. The other plot was not sprayed. The reduction in smutted heads due to the presence of head blight varied from 0 to 48 per cent, depending on the variety and on other factors. (U. S. Department of Agriculture and Minnesota Agricultural Experiment Station.)

Recent Changes in the Stem-rust Situation in Mexico. HARRAR, J. G., W. Q. LOEGERING, and E. C. STAKMAN. For more than a decade the distribution of races of *Puccinia graminis tritici* in Mexico has differed in different regions. Population trends of races in Northeastern Mexico have paralleled fairly closely those in the United States. In the southern wheat-growing regions of Mexico, on the other hand, only races 38, 59, and 19 have occurred in appreciable amounts, thus indicating relatively little effective interchange of inoculum between Southern and Northern Mexico. In 1945, however, races 56 and 17 were found with sufficient frequency to cause apprehension that they may be establishing themselves in Southern Mexico. Moreover, race 8 of *P. graminis avenae* was found in Mexico for the first time in 1945 and was present as far south as Mexico City, where it caused heavy infection on certain varieties that derived their stem-rust resistance from Richland oats. A number of unusual races of *P. graminis tritici* have been found occasionally. It had been suspected but not proved that native species of *Mahonia* might rust at high elevations and result in the production of such races. This suspicion was confirmed in 1945 when the unusual race 16 was isolated from heavily rusted *Mahonia* bushes growing in the mountains near Mexico City. (Rockefeller Foundation in Mexico, U. S. Department of Agriculture, and Minnesota Agricultural Experiment Station.)

Field and Greenhouse Studies on 16 Tobacco Hybrids and Varieties. HENDERSON, R. G. Seven commercial varieties of flue-cured tobacco and 9 lines resistant to root rot

(*Thielaviopsis basicola* and other organisms), selected from the progeny of crosses between commercial varieties and Turkish tobacco, were planted in 1/80-acre plots of soil only lightly infested with root-rot organisms. Plant height and leaf length and width were measured 5 times during the season. Leaves were harvested, cured, and graded in the usual manner. Plants of each of the 16 varieties were grown in pots in the greenhouse under conditions favorable for root-rot infection. When about 6 inches high, plants were removed from the pots; the roots were carefully washed, inspected, and scored according to the severity of infection. Six hybrids were highly resistant and 3 were intermediate. One commercial variety, Yellow Special, was moderately resistant but all the others were very susceptible. In the field, all of the resistant lines had wider leaves than the susceptible varieties, but leaf width was not directly proportioned to the degree of resistance. Since root rot was not a serious factor in the field test, the degree of resistance was not reflected in the yields.

Seed Treatment and Other Tests with Soybeans in Ontario. HILDEBRAND, A. A., and L. W. KOCH. In a 2-year series of field experiments involving plots planted by hand in a randomized, five-replicate design, the efficacy of Spergon (3 oz. per bu.), Arasan (2 oz.), and Fermate (2 oz.) was tested on seed lots of the variety, A. K. Harrow, which differed widely as to germinability, disease potentiality, and degree of seed-coat injury. With poor quality seed and the cracked-coat fraction of an otherwise high-quality seed, Spergon accelerated and increased emergence of seedlings and increased yield. In no other instance was increased emergence correlated with statistically significant increases in yield. While the beneficial effect of Spergon was consistent so far as seed of low quality or damaged seed were concerned, such was not the case in regard to seed of high quality. Spergon was consistently more effective than Arasan or Fermate, however, in reducing the incidence of disease or abnormality in early-season stands of plants. Results indicated a complete lack of correlation between yield and stand of plants, the stands differing numerically by a ratio almost as high as 4 : 1.

Wilting Induced in Tomato Cuttings by Toxic Substance from Crown-gall Bacteria. HODGSON, ROLAND, W. H. PETERSON, and A. J. RIKER. Sterilized filtrates from fermented cultures of *Phytomonas tumefaciens* (Smith and Town.) Bergey *et al.* induced a wilting of tomato cuttings, which affected largely the leaflets, while the stems and petioles remained turgid. Under standardized conditions, the approximate quantity of toxic substance in filtrates was measured by an assay involving filtrate concentration, solution intake, and severity of wilting (toxic index). The substance causing the wilting was thermostable in neutral solution, nonvolatile, relatively insoluble in most organic solvents, and dialyzable. After alcoholic fractionation of the filtrate, much of the toxic activity was found in a concentrate consisting largely of a previously studied glucosan. Several tests indicated an association between toxic substance and the polysaccharide. Therefore, the purified glucosan (previously reported) was tested and found to account for a large part of the toxic activity. Inulin and soluble starch (0.4 per cent aqueous solution) also induced similar effects. An accumulation of polysaccharide was found in the leaves of cuttings wilted by the filtrates; this accumulation was greater in the wilted portions than in the nonwilted portions of the leaves.

The Physiology and Pathogenicity of Strains of Corticium solani. HOUSTON, BYRON R. A physiologic and pathogenic comparison was made of a number of isolates of *Corticium solani* (Prill. and Del.) Bourd and Galz. (*Rhizoctonia solani* Kühn) obtained from a wide range of hosts. The fungus required small quantities of zinc, iron, copper, and manganese for most rapid growth in a synthetic nutrient solution. No other micro element was found to influence the growth rate at a level below that of toxicity. Zinc and iron proved most important; however, neither zinc nor iron alone or combined individually with copper and manganese significantly increased the growth rate. Only when both zinc and iron were present did copper and manganese further accelerate the growth rate. Isolates varied in ability to utilize the various carbon and nitrogen sources employed. The hexose sugars were the most readily available forms of carbon. Additions of certain amino acids accelerated growth particularly during the early stages. Isolates differed in pathogenicity. Some were completely nonpathogenic on all hosts tested; some had a high degree of specialization, being pathogenic on only one host; and others were pathogenic on nearly all hosts.

The Mode of Vector Feeding and the Tissues Involved in the Transmission of Pierce's-disease Virus in Grape and Alfalfa. HOUSTON, BYRON R., KATHERINE ESAU, and WM. B. HEWITT. Feeding punctures of the following vectors of Pierce's-disease virus on grape and alfalfa were studied: adults and nymphs of *Draeculacephala minerva* Ball and *Neokolla circellata* Baker; adults of *Helochara delta* Oman and *Carneocephala fulgida* Nott.

All vectors sought the xylem tissue in the process of feeding. The mouth parts reached xylem through the phloem or through the medullary ray. They passed between or directly through cells, including the tracheary elements. Using *D. minerva* on grape, 86.8 per cent of the 230 punctures studied reached the xylem, with 32.8 per cent of these passing through the phloem. On alfalfa 90.9 per cent of 451 punctures reached the xylem, and 15.6 per cent of these did not injure the phloem. The vectors transmitted the virus only when xylem tissue could be reached during the feeding process. Confinement of the 2 species of viruliferous vectors, *D. minerva* and *C. circellata*, to various portions of healthy grape and alfalfa plants resulted in the following percentage transmissions: whole plant, 82.1; whole stem, 80.0; exposed xylem strip, 65.1; phloem strip, 0.0. This appears to be the first record of insect transmission of a virus directly into xylem tissue.

Comparison of Several Fungicides as Dips for Seed Sweet Potatoes. JEFFERS, W. F., and C. E. COX. Various fungicides have been studied as prebedding dips for Maryland Golden seed sweet potatoes under field conditions. Several of the newer organic fungicides were superior to the generally recommended treatments. None of the newer materials controlled black rot better than did the standard treatments. However, they did not cause the delay in sprout production or decrease in the number of sprouts usually associated with dips of bichloride of mercury (1–1000), Semesan Bel (1 lb./7.5 gal.) and borax (1 lb./5 gal.). Outstanding during 2 seasons were Spergon (1 lb./4 gal.) and Phygon (0.5 lb./4 gal.). In 1945, Fermate (0.5 lb./4 gal.), Zerlate (0.5 lb./4 gal.), Thiosan (1 lb./4 gal.), Puratized N5E (1–4500) and Isothan Q15 (1–4500) also significantly increased the number of healthy sprouts produced.

Field Studies on the Mild Streak Disease of Black Raspberries. JEFFERS, W. F., and M. W. WOODS. During the past 10 years, mild streak has become the most serious disease of black raspberries in Maryland. Apparently virus in nature, its typical symptoms consist of dark-green or purplish, water-soaked streaks on new canes; curling of leaf tips; and dry, seedy fruits. For 4 years careful records have been maintained on the spread of mild streak in a planting originally streak-free. During this time the amount of the disease increased from 1.5 per cent in the first fruiting season to 46.7 per cent in 1945. Although infection at the end of the first season was rather uniformly distributed throughout the planting, there has been a much greater increase in disease incidence in the end of the field adjacent to an uncultivated area than in the end of the field surrounded by cultivated land.

A Virus Complex in Eryngium. JOHNSON, JAMES. Sea-holly (*Eryngium aquaticum* L.) is an umbelliferous perennial species sometimes grown as an ornamental. The presence of naturally occurring mosaic-like symptoms suggested inoculation to tobacco for virus determination. At least 3 different viruses were present. One of these viruses, which at first confused efforts at isolation, was a mild or attenuated form of the common tobacco-mosaic virus. *Eryngium* is, however, not very susceptible to this virus or to non-attenuated strains; no distinctive symptoms are evident; the progress of the virus in the host is very slow and its concentration is often very low. The more common virus in *Eryngium* is apparently new, although it possesses many similarities, in properties and host range, to the viruses of the cucumber-mosaic group. Protective inoculation tests, however, do not suggest any relationship to ordinary cucumber mosaic, and differential hosts do not indicate relationship to the delphinium- or celery-mosaic viruses, which the new virus resembles in other respects. A third virus producing almost uniform chlorosis over the entire area of tobacco leaves is occasionally present in *Eryngium*.

Water-congestion and Infection Experiments on Various Plant Species. JOHNSON, JAMES. Natural water-congestion was induced in plants of 30 species after exposures of 1 to 24 hours in a moist chamber. Barley, corn, beans, tomatoes, tobacco, peas, and wheat were congested most readily, but differences between and within varieties were common. Alfalfa, clover, celery, and carrot were among 20 other species in which there was no macroscopically visible evidence of congestion. Outdoor-grown plants generally congested more easily and were more highly predisposed to infection with representative parasites than greenhouse-grown plants. With tobacco, 100 per cent of the outdoor-grown plants congested readily and were infected with the wildfire organism without wounding, while there was no infection on the greenhouse-grown controls exposed in the moist chamber at the same time. Efforts to reproduce the favorable "outdoor conditions" in the greenhouse during winter months have not been successful. Other nonwounded greenhouse-grown plant species are highly susceptible to infection by certain parasites (*e.g.*, those of late blight of potato, anthracnose of bean, and rust of sunflower). With such diseases, it is as difficult to prove as to disprove the relation of congestive water to predisposition.

Normally resistant varieties of some species may often be predisposed to heavy infection by water congestion, provided other conditions are also favorable.

Control of Copper Spot on Fine Turf Grasses. KEIL, HARRY L. Copper spot (*Gloeocercospora sorghi*), as a new disease of fine turf grasses, was reported from Pennsylvania. It is now known to exist in many states, and it approached epiphytotic proportions on Piper Velvet Bent grass in Rhode Island during 1945. Spray treatments with 4 organic fungicides, at the rate of 10 gal. solution per 1000 sq. ft. of turf, were applied July 26 and 31. Treatments were replicated 8 times on blocks of 25 sq. ft. Average percentages of the area damaged by the disease were recorded September 10 and 27. Puraturf (phenyl mercuri triethanol ammonium lactate, 1 : 10,000), Puratized 177 (1 : 5000), and Zerlate (zinc dimethyl dithiocarbamate, 1.5 lb. per 100 gal.) gave a prolonged protection period of at least 41 days after treatment. Plots treated with Puratized 177 were still 99 per cent free from disease after 58 days, whereas disease had appeared on Puraturf and Zerlate plots. Up to 24 per cent of the grass was injured by disease on the nontreated plots, but plots treated with Phygon (2,3 dichloro 1,4 napthoquinone, 1 lb. per 100 gal.) had 34 per cent disease. Standard treatments had failed to control copper spot in other experiments.

Inheritance of Pathogenicity and Sex Reaction in Venturia inaequalis. KEITT, G. W., CURT C. LEBEN, and J. R. SHAY. A monascosporic line of *Venturia inaequalis* that incites typical scab lesions on Haralson and Wealthy and flecks on Yellow Transparent and McIntosh apple leaves was crossed with one that incites the converse disease reactions on these 4 varieties. The 8 ascospores were isolated in serial order from each of 35 progeny asci and the resulting lines tested for pathogenicity to the leaves of each of the 4 apple varieties and for sex reaction. In each ascus tested, segregation for pathogenicity to each variety as indicated by the lesion or fleck reaction was in 1 : 1 ratio. Of the 140 pairs of lines, 56 showed parental combinations for pathogenicity (inciting lesion or fleck on Haralson and Wealthy and the converse reaction on Yellow Transparent and McIntosh) and 84 showed new combinations (inciting lesions on all 4 varieties or flecks on all). There was no evidence of linkage between the alleles governing pathogenicity to Haralson and Wealthy and those governing pathogenicity to Yellow Transparent and McIntosh. The latter were shown to be linked with those governing sex reaction. The data on second division segregation indicate that the loci for pathogenicity dealt with herein are more than 33 cross-over units from their respective centromeres.

Corn Pericarp Injuries and Seedling Diseases. KOEHLER, BENJAMIN. Corn-seedling diseases under present seed-producing and seed-processing methods in the Corn Belt are caused chiefly by organisms residing in the soil, and the extent of damage is governed considerably by the extent of pericarp injury. A break directly over the plumule is the most injurious type. Breaks in the crown which expose the soft endosperm are second in importance. Breaks in the pericarp over the germ area to one side of or beyond the plumule, or directly over the radicle, are still less important. Of least importance are removal of the tip cap and breaks which expose only horny endosperm. In controlled inoculation experiments some strains of *Penicillium oxalicum* have been the most damaging to corn when the pericarp was injured, while some species of *Pythium* were second in importance. Isolation from naturally infected seedlings grown from injured seed in field soil seldom yielded *Penicillium oxalicum* but species of *Pythium* were commonly found. Considerable pericarp injury appears to be unavoidable under present processing methods. Fortunately, much benefit is obtained by treating with seed protectants. Arasan and Spergon have given somewhat better results on injured seed than the mercurials.

Viability of Stored Seeds of Forage Crops Treated with Different Fungicides. KREITLOW, K. W., and R. J. GARBER. Seeds of alfalfa, red clover, Ladino clover, and Sudan grass were treated with New Improved Ceresan, Semesan, Arasan, Spergon, and Yellow Cuprocide. Samples of the treated seeds along with nontreated controls were stored in closed and open containers at 10° and at 25° C. Germination was tested periodically in Petri dishes and in flats of soil. After 30 months, treated seeds of alfalfa, red clover, and Ladino clover stored at 25° showed no appreciable injury from any of the fungicides tested. There was no difference in germination between seeds stored in open and closed containers at 25°. Germination of Sudan grass treated with New Improved Ceresan was noticeably reduced 1 month following treatment and within 6 months none of the treated seeds germinated, regardless of storage temperature or condition. None of the other fungicides reduced germination of Sudan grass. At 10°, germination of treated and nontreated seeds of all species stored in closed containers was much better than germination of seeds stored in open containers. (U. S. Regional Pasture Research Laboratory and Pennsylvania State College.)

Reactions to Crown Rust in Festuca elatior and F. elatior var. arundinacea. KREITLOW, K. W., and W. M. MYERS. Inoculation of many plants in the greenhouse corroborated field observations that *Festuca elatior* was generally susceptible to crown rust (*Puccinia coronata*) while *F. elatior* var. *arundinacea* was usually resistant. Of the many collections of *F. elatior* tested, 3 plants from 1 collection were immune from rust. Additional material, which varied in rust reaction from susceptible to immune, from the same and neighboring fields proved to be *F. elatior* var. *arundinacea.* Cytological studies of the species indicate that the small, fine-leaved *F. elatior* has 14 somatic chromosomes while the tall, coarse *F. elatior* var. *arundinacea* is a hexaploid and has 42 chromosomes. Hybrids between the two were completely sterile.

Virus Inhibitors in Spinach Extract. KUNTZ, J. E., and J. C. WALKER. *Cucumber virus 1, turnip virus 1,* and *tobacco virus 1* are not readily recovered from infected spinach by mechanical juice extraction although the first 2 viruses are easily transferred by aphids. Crude spinach extract added in equal proportions to infectious plant juice containing these viruses usually completely inhibits infectivity. Spinach extract contains 2 distinct inhibitive entities. One of these, inhibitive to *tobacco virus 1,* is thermolabile, nondialyzable, unstable in extremely acid and extremely alkaline solutions, precipitated by alcohol, and adsorbed by some activated charcoals. Infectivity of noninfectious mixtures of spinach extract and infectious juice can be restored by removal or adsorption of the inhibitor. The second inhibitor, inhibitive to *turnip virus 1* but not to *tobacco virus 1,* is thermostable, dialyzable, is not precipitated by alcohol, is not readily adsorbed on activated charcoals. Infectivity of a noninfectious mixture is restored by addition of calcium chloride.

Serological Relationship between Potato Latent Ring-spot and Virulent Ring-spot Viruses. LARSON, R. H. Precipitin and precipitin-absorption tests indicate that the virulent potato ring-spot virus causing a mottle and necrosis in certain varieties of American potatoes in the field is a strain of the latent potato ring-spot virus. No significant difference was detected between the ability of the virulent ring-spot virus or the latent ring-spot virus to induce antibody formation in rabbits; both sera reacted at the same dilution and showed high titre. Reciprocal precipitin tests showed that the potato latent mottle, latent ring-spot, and virulent ring-spot viruses are serologically indistinguishable. There were no detectable differences in isolates of the virulent ring-spot virus from Wisconsin-grown Chippewa, Katahdin, Red Warba, Sebago, or Pontiac varieties and isolates from the Sebago variety from Minnesota, Michigan, or Maine. Veinbanding virus (aphid-transmitted component of rugose mosaic) was not cross-active with the latent mottle, the latent ring-spot, or the virulent ring-spot virus antisera. The virulent potato ring-spot virus is designated as a strain of the potato mottle (latent) virus, ring-spot group.

The Cytology of Ustilago striaeformis from Poa pratensis. LEACH, J. G., and MARY ALICE RYAN. This fungus completes its life cycle in culture on agar media. The germinating chalmydospore does not form a true promycelium but forms a branched germ tube of indeterminate growth. No sporidia are produced. The chlamydospore contains a fusion nucleus that undergoes reduction division soon after germination begins. A chance reassortment of nuclei takes place in the branching germ tube or resulting mycelium, and karyogamy occurs without an intermediate dikaryophase. Some cells may remain in the haploid condition and give rise to haploid mycelium. The diploid cells continue to multiply vegetatively, forming a characteristic fragmenting mycelium that is readily distinguished from the typical radiating haploid mycelium. The diploid mycelium in its typical form of growth breaks up into short fragments, each cell of which contains a single, large, diploid nucleus. A single cell of the diploid mycelium may be transformed directly into a chlamydospore. Thus, the fungus appears to be homothallic, but produces both haploid and diploid mycelium. It has no true dikaryophase.

Control of Cucumber Anthracnose with Fermate. LEBEAU, F. J. Successful culture of fall cucumbers in southeastern Louisiana depends on satisfactorily controlling downy mildew, and although copper compounds often injure the foliage, Bordeaux mixture and various copper dusts have been generally used. In the last 2 years, mildew control was complicated by epidemics of anthracnose, which the standard fungicides did not satisfactorily control. In 1944, only Bordeaux mixture, 4–4–50, and Fermate dust, 10–100, protected the plants from anthracnose. In 1945, when a severe epidemic of anthracnose destroyed many fields by the middle of the harvest season, Fermate, 10–100, completely protected the plants from anthracnose and from downy mildew, without foliage injury. Bordeaux mixture and Dithane were more satisfactory than the copper dusts but did not give satisfactory control during the last quarter of the harvest. Acre yields of 233, 244, 291, and 461 bushels were obtained, respectively, in the plots treated with Bordeaux mix-

ture, 12 per cent tribasic copper sulphate dust, 3 per cent Cuprocide dust, and 10 per cent Fermate dust. Low yields in the Bordeaux mixture plots were attributed to foliage injury.

Relations of Carbon and Nitrogen Sources and Vitamins to the Growth of Pathogenic and Nonpathogenic Lines of Venturia inaequalis. LEBEN, CURT C. The physiology of 4 wild-type pathogenic and 3 nonpathogenic cultural mutant lines was studied *in vitro*. At 0.5 per cent concentration, 39 carbon sources were tested in a mineral salt-agar medium containing 1 g. per liter of malt extract. The most favorable compounds were cellobiose, dextrin, fructose, glucose, maltose, mannitol, mannose, melezitose, raffinose, and sucrose. Twenty-one nitrogen sources, mostly amino acids, were tested in a similar medium containing glucose and nitrogen equivalent to 0.003 M KNO_3. The best compounds for most lines were arginine, glutamic acid, histidine, proline, urea, NH_4NO_3, $(NH_4)_2SO_4$, and KNO_3. Ability to utilize the carbon and nitrogen sources varied among the lines. In a mineral salt–glucose medium containing purified agar, the following substances were tested singly and in combination: adenine sulphate, ascorbic acid, *b*-alanine, biotin, calcium pantothenate, choline chloride, a "folic acid" concentrate, guanine, inositol, niacin, *p*-aminobenzoic acid, pimelic acid, pyridoxine, riboflavin, thiamine, uracil, and xanthine. Only thiamine had a beneficial effect, and it was greater for some lines than for others. When thiamine was present, substances in "vitamin-free" casein hydrolysate also stimulated growth. None of the observed differences in the physiology of the lines was clearly associated with their pathogenic capabilities.

Control of Bacterial Pustule of Soybean by Dusting. LEHMAN, S. G. In 1944, favorable results were obtained from an experiment designed to control bacterial pustule of soybean by dusting growing plants with fungicides. The experiment was repeated with amplification in 1945. The dust preparations used were: (1) copper-clay containing 7 per cent metallic copper from Tenn. 34, (2) copper-sulphur having 7 per cent metallic copper from Tenn. 34, (3) copper-talc containing 7 per cent copper from Copper Compound A, (4) 20 per cent Fermate in Pyrox talc, (5) 20 per cent Zerlate in Pyrox talc, (6) 325-mesh sulphur, (7) 10 per cent Fermate in sulphur, (8) 5 per cent DDT in sulphur. Six applications of each dust were made. Only dusts containing copper reduced bacterial pustule. In control rows not dusted, less than 5 per cent of the leaves were entirely free of disease. On the remaining 95 per cent damage ranged from slight to severe. In rows dusted with copper, 37 to 74 per cent of the leaves were entirely free of disease; the remaining leaves showed little injury, few or none being severely damaged. Plots dusted with copper yielded 4.9 bushels per acre more than plots not dusted. Sulphur dust reduced yields about as much as copper increased them.

Field Tests with Dow 9 on Cottonseed. LEHMAN, S. G. From preliminary greenhouse tests on cottonseed treated with hitherto unused preparations, Dow 9, containing 100 per cent of zinc salt of 2,4,5-trichlorophenol, was selected for field trials in 1944. It was compared with New Improved Ceresan, the standard material for cottonseed treatment. Dosages of 1.5, 3, and 6 g. of dust per 1000 g. of seed were used. Dow 9 at the lowest dosage gave seedling stand increases equal to those from Ceresan. Higher doses of Dow 9 gave smaller increases. In 1945, Dow 9A, containing 25 per cent, and Dow 9B, containing 50 per cent of zinc salt of 2,4,5-trichlorophenol, were each used at 1.5, 3, and 6 g. per 1000 g. of seed. New Improved Ceresan increased surviving seedlings 90.3 per cent; 9A, 124.8 per cent; and 9B, 130.7 per cent. The 3 to 1000 doses of both Dow preparations gave increases approximately equal to higher doses. In another test, seed treated with 3 and 6 g. of Dow 9B per 1000 g. of seed and stored 7 and 42 days in grain sacks gave higher seedling survival than Ceresan-treated seed stored for the same periods. Emergence from seed treated with 9B did not differ significantly for the two storage periods.

Outstanding Diseases of Agricultural Crops and Uses of Fungicides in the United States. MCCALLAN, S. E. A. To facilitate research on new chemicals as possible fungicides and specifically to select rapid methods for evaluating them in laboratory and greenhouse, it is necessary to know which plant diseases are outstanding on a national basis. A tentative method for determining those diseases is based on an index obtained from the product of the logarithms of the estimated annual percentage loss (from Plant Disease Reporter) and of farm value. The indices, thus obtained, of 36 outstanding diseases are recorded together with average annual losses, 10-year fluctuations, and present major control measures. Tables showing estimated annual consumption of fungicides are arranged according to chemicals, crops, and diseases. Thus may be seen the most outstanding potential uses for new or improved fungicides, and likewise the diseases for which it is desirable to develop test methods. Among certain outstanding diseases there is need for better fungicides: (a) seed treatments—corn and cotton seedling blights, oat smuts; (b) sprays and dusts—apple scab, potato tip burn and late blight, peach and cherry brown

rot, pear blight, peanut leaf spot, tomato blights. Adequate methods for fungicide evaluation are available in certain cases cited, but further development and standardization are necessary for many.

A New Helminthosporium Disease of Oats. MEEHAN, FRANCES, and H. C. MURPHY. A new species of *Helminthosporium* pathogenic on certain oat varieties was isolated in November, 1944, from a diseased seedling of Tama oats grown in the germinator. Numerous field isolations of this fungus were obtained during 1945. Infected seedlings showed necrosis of first internode, scutellum, and seminal roots. Affected leaf blades were dull bluish-gray, had reddish brown full-length stripes 1 to 3 mm. wide, and their margins withered. Wilting of the leaves and death of severely infected plants followed a few days after the first leaf discolorations. Infected adult plants in the field had a brownish translucence of the lower internodes and tended to break over near the base. Late in the season the nodes were covered with abundant conidiophores, and plants ripened prematurely. Normal conidia were light olivaceous, slightly curved, rounded at the base, widest near the center and tapering toward the apex, moderately thin-walled. Germination was polar. The maximum coinidial measurements observed were: length, 111 μ; width, 25 μ; number of septa, 11. The modes were 75 μ, 18 μ, and 8 μ, respectively. The organism was isolated frequently also from timothy. (Iowa Agricultural Experiment Station and U. S. Department of Agriculture.)

Soil Actinomycetes in Relation to Panama Disease of Banana. MEREDITH, CLIFFORD H. Nine cultures of Actinomycetes, isolated from soils of several banana plantations and demonstrated to be antagonistic to *Fusarium oxysporum cubense* in the laboratory, were applied near the stools of banana at planting time in an experimental planting at Orange River, Richmond, Jamaica, B. W. I. The field was infested with the *Fusarium* that causes Panama disease. The Actinomycetes were grown in flasks, on guinea grass with soil and water. There were 15 plants in each plot and 7 replicates of each treatment: Actinomycetes from other fields, Actinomycetes from other fields plus grass mulch, Actinomycetes from Orange River field plus grass mulch, grass mulch alone, and the check with no treatment. At 5 months after treatment the banana plants treated with Actinomycetes were larger than check plants. At 12 months there were no statistically significant differences in the Panama disease in the plots.

Some Phenols as Agricultural Fungicides. MEULI, LLOYD J., and BERNARD J. THIEGS. Results of greenhouse and field tests since 1943 indicate that dust compositions of zinc 2,4,5-trichlorophenate (Dow Seed Fungicide 9A and 9B) for seed treatment effectively control certain seed-borne pathogens and protect against various soil-inhabiting organisms that cause preemergence damping-off. The 2,4,5-trichlorophenol was more effective than 2,4,6-trichlorophenol. Of the several salts tested as seed fungicides, the zinc salt of 2,4,5-trichlorophenol was most consistently effective in producing high seedling emergence. Testing has been most intensive on cotton and peas, but results also show that the treatment has value for many other agricultural seeds. The chemical is heat-stabile and is difficultly soluble in water and the usual organic solvents.

Relation of Sour Cherry Yellows to Yield. MOORE, J. DUAIN. For several years comparative yield records were taken on yellows and yellows-free trees in 2 commercial orchards in Door County, Wisconsin. One orchard was 21 years old, the other 13, in 1945. Both were surveyed for occurrence of yellows before yield records were taken and annually thereafter. The yellows trees of each orchard were classified according to the year in which the disease was first recorded. Each diseased tree was paired with an adjoining, comparable, yellows-free tree. Yield data from the 2 orchards, recorded in pounds per tree, were very similar. Though individual trees varied considerably in the rate and extent of reduction in fruitfulness, the general trend was for little or moderate reduction in the first or second year following first observation of symptoms and a greater reduction in the ensuing 2- or 3-year period. In 1945, in the 13-year-old orchard, for the group of trees known to have been diseased 5 years or more the average reduction in yield was approximately 50 per cent (16 pairs of trees); in the 21-year-old orchard, approximately 62 per cent (53 pairs of trees). On the average the trees in the older orchard had been diseased longer.

Relation of Temperature to Expression of Symptoms of Sour Cherry Yellows and Necrotic Ring Spot. MOORE, J. DUAIN, and G. W. KEITT. Potted Montmorency cherry trees were budded from 3 sources of sour cherry yellows and placed in greenhouses with approximately constant temperatures of 16°, 20°, 24°, and 28° C., respectively. Two trees budded from each source were placed in each greenhouse. During 2 greenhouse seasons, yellows leaf symptoms were expressed only at 16° C. In the third season all

trees were placed at 16°, and all except 1 that had been at 28° for 2 seasons expressed yellows symptoms. Potted Montmorency trees budded from a source of necrotic ring spot and put in controlled temperature greenhouses expressed necrotic ring-spot symptoms over the entire range from 16° to 28°. Symptoms were expressed more rapidly and with more necrosis at the higher temperatures. Best leaf-symptom expression occurred at 20° or 24°. In greenhouse experiments with *Prunus pumila, P. virginiana, P. americana,* and *P. besseyi* budded from a source of necrotic ring spot, symptom expression was either very poor or lacking at night temperature of approximately 10° C. and day temperature of 16° to 24° C. Symptom expression occurred on all 4 hosts and was more general and conspicuous at 24° to 28° C., day and night.

Spraying and Dusting Potatoes in Michigan in 1945. MUNCIE, J. H., and W. F. MOROFSKY. At Lake City, Michigan, potatoes sprayed with Bordeaux DDT 8–12–1–100 produced significantly higher yields than those sprayed with Bordeaux 8–12–100 alone and those sprayed with the fixed coppers, Tribasic copper sulphate, Dow F–48, copper oxychloride sulphate, Copper Compound A, and Yellow Cuprocide, to which had been added 0.5 lb. zinc sulphate and 1 lb. hydrated lime per 100 gal. Plants sprayed with fixed copper plus Z–39 (dichloro diphenyl dichloro ethane), Pyrethrum, B–72 (beta beta dithio cyano ethyl ether), Dithane, or Zerlate yielded significantly less than those with Bordeaux DDT 8–12–1–100 or Tribasic DDT. Indications were that the excess lime in the Bordeaux had no deleterious effect upon DDT and that excess lime in itself did not cause decreased potato yields when leafhoppers or other leaf-feeding insects were reduced to a minimum. Leafhopper control was best with DDT followed by Pyrethrum, B–72, Z–39, and nicotine sulphate. Tests of 22 dusting materials were inconclusive because of drifting of dusts containing insecticides for control of leafhoppers. In spray tests in 9 counties of the Upper Peninsula of Michigan 2 fixed coppers plus DDT were compared with Bordeaux 8–12–100 and fixed copper-zinc sulphate-lime. Addition of DDT increased yields over Bordeaux or fixed copper-zinc sulphate-lime and decreased markedly leafhopper, flea-beetle, and aphid populations.

Reaction of Oat Varieties to a New Species of Helminthosporium. MURPHY, H. C., and FRANCES MEEHAN. Oat varieties possessing the "Victoria type" of crown-rust resistance were highly susceptible in the field and greenhouse to a new species of *Helminthosporium,* while varieties lacking this "Victoria" rust resistance were resistant. No exceptions to this were observed among 248 oat selections tested in the greenhouse. Named Victoria-hybrid selections such as Boone, Tama, Vicland, Cedar, Osage, Neosho, Forvic, Fultex, and Letoria were susceptible. The Bond-hybrid selections, Clinton, Benton, Eaton, Bonda, Mindo, and Camellia, were resistant, as were older varieties such as Iogold, Richland, Gopher, Huron, Fulghum, Marion, Erban, Vanguard, Lee, Fulwin, and Red Rustproof. F_2 populations of 8 hybrids, each involving one Victoria crown-rust-resistant parent, segregated 3 susceptible to 1 resistant when inoculated with the *Helminthosporium.* Other populations of these crosses segregated 3 resistant to 1 susceptible to race 45 of crown rust. These data suggest complete linkage for the genes controlling "Victoria type" of crown-rust resistance and susceptibility to the *Helminthosporium.* This fungus has been isolated from Victoria-hybrid selections grown in Texas, Iowa, Pennsylvania, North Dakota, and Montana in 1945. At the Iowa Experiment Stations, Osage, Victoria × Rainbow, and (Victoria × Richland) × Bannock were reduced 50 per cent in yield by the attack of the fungus. Seed-borne infection was effectively controlled with New Improved Ceresan. (Iowa Agricultural Experiment Station and U. S. Department of Agriculture.)

Relative Effectiveness of Certain Organic and Inorganic Fungicides for the Control of Phytophthora infestans on Potatoes. NAGEL, C. M. Excellent control of epiphytotic late blight was obtained with 4 of the 8 fungicides tested. Bordeaux, Yellow Cuprocide, Phygon (2,3-dichloro 1,4-naphthoquinone), and Dithane (disodium ethylene bisdithiocarbamate) afforded uniformly low percentages of disease from 3 foliar spray applications. Phygon, at 1.5 pounds per 100 gal. water, increased yields by 70.3 per cent when compared to the check. Yellow Cuprocide, Dithane, and Bordeaux, although as effective as Phygon in disease control, produced smaller increases (44.3, 16.7, and 14.9 per cent, respectively). Zerlate (zinc dimethyl dithiocarbamate) and Copper Compound A produced increases in yield of less than 10 per cent. Small decreases in yield were obtained with Isothan Q15 (lauryl isoquinolinium bromide) and Puratized N5E. A randomized split-plot design with 3 replications was employed in this experiment with Early Ohio potatoes. One half of each plot was treated with a dust of DDT, 2,2-bis (p-chlorophenyl) 1,1,1,-trichloroethane, for the control of the 3 major insects common to potatoes in South Dakota, namely, leafhopper, flea beetle, and the Colorado potato beetle. Ten sweeps yielded an average of less than 6 insects per plot; hence, differences in disease control and yields are very largely attributable to the relative effectiveness of the various fungicides. All fungicides were applied as sprays at the recommended dosages.

Availability of Copper in Dust as Influenced by Various Diluents. NIKITIN, A. A. There are several inert diluents available for use in pesticidal dust mixtures. There is considerable variation in chemical and physical properties of these diluents, which have an effect on the rate of flow, adherence, and effectiveness of the final dust mixtures for crop protection. Emphasis was placed in this study on adherence and availability of soluble copper. This availability depends greatly upon the sorption capacity of various diluents. Results secured from these tests show that a certain correlation exists between surface tension of the water suspension of diluents and their sorption capacity for soluble copper. Study on the sorption capacity of copper by various diluents shows that pyrophyllite clay absorbs much less copper than Eastern Magnesia and especially Loomkill. This sorption capacity is in direct relation to the base exchange capacity of the diluent. Zinc salts are more readily sorbed by diluents than copper and can be used to increase the amount of soluble copper available for the control of heavy infestation. Neutral sodium salts reduce the concentration of available copper due to increased sorption capacity of the diluent.

Use of D–D Mixture Permits Two Crops of Watermelons per Year in Breeding Program. PARRIS, G. K. Applying D–D mixture to Norfolk sand known to contain *Heterodera marioni* and suspected of containing the meadow nematode, immediately following a spring crop of melons, permitted growth to maturity of a second crop of melons (August to September) at Leesburg, Florida. Five cc. of D–D per hole was applied in holes 6 inches deep, 12 inches apart in rows that were 12 inches apart. Approximately 15 square feet of soil were treated per hill. With roughly 1200 hills per acre, the actual quantity of D–D used was 175 pounds per acre. The soil temperatures, 6 inches deep, ranged from 81° to 90° F. in the day to 78° to 82° F. at night. There was no evidence of injury to seeds planted 10 days after soil treatment. On nontreated soil the survival of Fusarium-resistant Blacklee was 25 per cent and most plants died when runners were 3 feet long. On treated soil, 69 per cent of Blacklee lived and 72 per cent hybrid plants survived. No fruits were obtained from plants on nontreated soil. Growing 2 crops of melons a year will speed up markedly the present program of breeding for resistance to cucurbit anthracnose and downy mildew.

Occurrence and Importance of Cankers and Rots in Deciduous Forests in Quebec. POMERLEAU, RENÉ. Surveys in several localities in Quebec were made between 1942 and 1944 to obtain information on the health of deciduous forest trees. At the Forest Experimental Station at Duchesnay, 3147 trees distributed in 115 sample plots were studied. The data obtained were completed by surveys in sugar maple groves in 17 localities, and by stem analysis of 279 trees in 4 sample plots in a white birch stand. At Duchesnay, 13.9 per cent of the trees were infected with at least one canker, and 21 per cent were more or less severely rotted. Close examination of 930 trees in maple groves showed that 22.1 per cent of them were cankered and 18.4 per cent rotted. In the white birch stand, 9.5 per cent of 279 trees were cankered and 14.3 per cent rotted. In all these stations, *Nectria* canker was the most prevalent and injurious, especially to maple, white birch, and yellow birch, and the incidence of infection varied with site. *Eutypella* canker occurred on 3 to 8 per cent of the maples, especially on the young trees. *Diatrype macounii, Poria punctata,* and *Pholiota squarrosoides* were found for the first time to be responsible for canker. *Fomes igniarius* caused the most widespread rot in maple, birch, and aspen, but other fungi, taken together, produced comparable losses.

Variability in Phoma lingam. POUND, GLENN S. A Phoma species has been found as a pathogen of cabbage and Chinese cabbage seed plants in the Puget Sound area of Washington, causing minor leaf-spot and stalk-rot injury. It is morphologically similar to *Phoma lingam* (Tode) Desm., produces typical black leg on members of *Brassica oleracea* L., attacks a wide range of cruciferous plants, and differs only slightly in pathogenicity from *P. lingam.* Distinct strains of monosporic origin have been obtained from *P. lingam,* these differing in type and rate of growth, staling, and amount of sporulation. Only slight differences in conidial size occur between these strains, but marked differences in shape and size of pycnidia are found. Slight differences in pathogenicity have been observed. Numerous saltants tend to link the strains. Because of the extent of variability in *P. lingam,* the Puget Sound isolate is considered tentatively to be a variant of this species. (Washington Agricultural Experiment Stations, Vegetable Seed Production Laboratory, Mount Vernon, Washington.)

Cabbage Varietal Reactions to Mosaic Viruses. POUND, GLENN S. For the past 3 years commercially important cabbage varieties have been tested for their relative susceptibility to mosaic viruses. In experiments in which relative susceptibility was determined by a disease-index system the varieties tested showed a distinct gradient, but they could be divided roughly into 3 groups. In the least susceptible group were Wisconsin All Sea-

sons, Stein's Flat Dutch, All Head Select, Succession, and Globe. In the intermediate group were Jersey Wakefield, Charleston Wakefield, All Head Early, Copenhagen Market, Golden Acre, Marion Market, Midseason Market, Glory of Enkhuizen, Round Dutch, and Premium Late Flat Dutch. The most susceptible group contained the ballhead varieties, namely Wisconsin Hollander, Bugner, Penn State Ballhead, Wisconsin Ballhead, and Hollander. The first 3 in the last group were only moderately susceptible through midseason but developed very severe symptoms by the time heads were mature. The relative susceptibility of the various varieties was about the same when either the cabbage A strain or the cabbage black-ring strain of *turnip virus 1* was combined with the cabbage B strain of *cauliflower virus 1* to produce the mosaic disease. (Washington Agricultural Experiment Stations, Vegetable Seed Production Laboratory, Mount Vernon, Washington.)

Varietal Reaction of Cotton to Bacterial Blight. RAY, W. W. Approximately 250 varieties and selections of cotton have been tested in the seedling stage to determine their reactions to the bacterial-blight organism. This technique involved soaking acid-delinted seed in a bacterial suspension, planting this seed in moist sand, harvesting the seedlings one week later, and scaling the disease intensity by means of a disease index based on the number of healthy and diseased cotyledons and the nature of the lesions. The results obtained by means of this rapid technique showed good correlation with those obtained by inoculating older plants in the field. With but few exceptions, commonly grown commercial varieties were the most susceptible to blight. Certain lines such as Stoneville 20, Stoneville 62–1, Stoneville 462, and Oklahoma Triumph 92–1 had considerable resistance. The artificial inoculation of seedlings and field plants to determine varietal reaction to blight is proving very useful in cotton breeding.

A Rusty Mottle-like Virus Disease of the Sweet Cherry in Utah. REEVES, E. L., and B. L. RICHARDS. A virus disease of sweet cherry resembling rusty mottle occurs in destructive proportions in Utah orchards. Incidence of transmission by bud graft is high, approaching 100 per cent. The virus rapidly becomes systemic in the tops of inoculated trees and induces in sequence retarded blossoming and leaf development in the spring, brown necrotic leaf areas with shot-hole effect, early senescence and extensive defoliation, rust-colored chlorotic spots, premature autumn senescence, roughening of bark, and bud killing. Rangy limbs with scant foliage, usually confined to terminal portions of branches, ultimately result. In early breakdown of chlorophyll resulting in ring-spot and line patterns, in early leaf senescence and subsequent defoliation prior to fruit ripening, the disease in Utah follows the same sequence as and resembles essentially rusty mottle described for Washington. In Washington, leaf necroses, pronounced devitalization of the tree, blossom and leaf retardation, and bark roughening do not occur. Consideration has been given to the possibilities that (1) the virus in Utah is a more virulent form, (2) the disease in Utah results from a combination of viruses including the rusty mottle virus, (3) the environment influences expression, (4) a different virus is involved.

Wilt and Decline, a Virus Disease of Sweet and Sour Cherries in Utah. RICHARDS, B. L., E. L. REEVES, and LEE M. HUTCHINS. "Wilt" and "dieback," common diseases in the sweet and sour cherry, have long been observed in Utah orchards. These well-known diseases assume additional significance because buds taken from red-leaf-diseased chokecherry plants and grafted into sweet and sour cherry varieties on Mahaleb rootstock induce a characteristic cherry wilt during the season following inoculation. A definite decline occurs in trees that survive the wilt. The wilt and decline, artificially produced, resemble in many respects the diseases observed in the orchards. Decline is progressive and, although some of the inoculated trees die within 2 years, others survive for a number of years. Evidence indicates that both wilt and decline result either from the direct effect of the virus or from the effect of products of the disease on the Mahaleb rootstock. The virus failed to pass from diseased sweet cherry branches through Mahaleb understock to healthy branches of the sweet cherry separately top-worked on Mahaleb. Red leaf in the chokecherry has been experimentally connected with the form of Western X disease of the peach in Utah. A relationship between the cherry wilt and Western X in peach appears to be demonstrated.

Effect of Soil Nutrients on the Development or Suppression of the Leaf-roll Symptom in the Green Mountain Potato Grown in the Greenhouse. RICHARDS, M. C., R. C. JONES, and STUART DUNN. From December to March, when days are short and frequently cloudy, the leaf-roll symptom can be masked in the Green Mountain variety of potato grown in the greenhouse by adding to the soil at planting time certain soil nutrients. When tubers with severe net necrosis were planted in 6-inch pots to which 11 g. sodium nitrate or 11 g. of 8–16–16 fertilizer had been added, the leaf-roll symptom was absent in from 75 to 100 per cent of the plants. Plants from sections of the same tubers planted in pots with 11 g.

superphosphate or 11 g. potassium chloride had well-developed symptoms in 87 to 100 per cent of the cases. Plants in the pots containing nitrogen or complete fertilizer showed a higher percentage of masking when the soil was kept relatively dry. The masking was less when the tests were repeated in April and May, and no masking occurred when similar tests were made in the field during the summer. There appears to be a relationship between light conditions and nitrogen nutrients with respect to the suppression of the leaf-roll symptom in the Green Mountain potato.

Geographic Distribution and Control of Tilletia spp. in Mexico. RODRIGUEZ V., JOSÉ. Bunt is second to stem rust in importance as a disease of wheat in Mexico. Losses up to 40 per cent have been recorded in fields where nontreated seed was sown. While the disease occurs wherever wheat is grown in Mexico, greatest losses occur in the northern wheat-growing region. *Tilletia levis* comprised 87.09 per cent of collections made in 1945 and was found in all parts of Mexico where wheat is grown. *Tilletia tritici,* which represented 12.91 per cent of the 1945 collections, has been found only in southern Mexico. In this area spring and durum types of wheat predominate while in the North, spring types, semi-winter, and winter types occur in that order. Regional variety tests are in progress, a seed treatment campaign is getting under way, and improved varieties are being developed.

Observations on Leaf and Stripe Rust of Wheat in Mexico. RODRIGUEZ V., JOSÉ. Field tests in central Mexico demonstrated that a number of improved U. S. wheat varieties were highly susceptible to the races of leaf rust (*Puccinia rubigo-vera*) in Mexico. Pilot, Rival, Regent, Renown, and Newthatch were susceptible. Mida was resistant. Several selections of Kenya were moderately susceptible, and three durums, Mindum, Kubanka, and Arnautka, rusted rather heavily. Carlton and Stewart were resistant. Most of the local varieties were susceptible to leaf rust. Stripe rust (*Puccinia glumarum*) attacked many local wheats during late winter or early spring when they were heading. Some of the Kenyas also were susceptible as were many lines of Renacimiento × (41–116). Lines from Trigo Supreme × (41–116) were resistant.

A Dwarfing and Witches' Broom on Corn in Iowa. SEMENIUK, G., I. E. MELHUS, J. R. WALLIN, C. L. GILLY, and MURIEL O'BRIEN. A dwarfing, branching, and witches'-broom disease on maize has occurred sporadically in Iowa during the last 20 years. This past season, 1945, it was more common than at any previous time. In some low lands in the north central part of the State, from 2 to 50 per cent of the plants were diseased. Many hybrids were affected. The dwarfed plants were often less than 2 feet tall and excessively branched. In some cases the plants were only a foot tall and dead when healthy corn was in the milk stage. In certain other cases the plants were not stunted but were excessively tall, with almost twice the normal complement of leaves and with few branches. Numerous witches' brooms were produced by the terminal meristems of the side branches and the floral organs. Leafy shoots developed from the floral organs. Often these witches' brooms were on partially dwarfed and much-branched plants. These symptoms of dwarfing and excessive branching were like those caused by *Sclerospora graminicola* and already described on corn and other hosts. This pathogen was prevalent on *Setaria viridis* in the cornfields. Weather conditions in the spring were cool and wet, favoring *Sclerospora* infection.

Studies on the Milo Disease. SLAGG, C. M., and L. E. MELCHERS. Laboratory and greenhouse studies on the root rot of milo, or "milo disease," from 1939 to 1943 indicate that fungi other than *Pythium arrhenomanes* Drechs. may be mainly responsible as causal agents. Pure cultures of *P. arrhenomanes, Fusarium moniliforme, Corticium vagum,* and other fungi isolated from diseased milo plants, were separately increased in steamed soils which were later planted with seed of resistant and of susceptible strains of milo. The comparative growth of resistant and susceptible strains in any soil was used as a measure of the severity of the root rot in that soil. Appearance of the milo disease in steamed, noninoculated soils led the writers to suspect seed transmission, and this was proved experimentally. In 1941, 22 different lots of milo seed grown in 1939 and 1940 at Garden City and Ft. Hays, Kansas, were tested, and 8 of these seed lots transmitted the milo disease. In 1942, 27 different seed lots were tested, of which 10 transmitted the milo disease. One seed lot more than 3 years old infested soil in which it was sown.

Studies in the Northern Great Plains upon the Effect of Crop Sequence on Root-rot Losses in Cereals and Grasses. SPRAGUE, RODERICK. Field and greenhouse studies have shown that crop-rotation practices have had certain effects on the parasitic activity of *Pythium arrhenomanes* Drechs., *P. debaryanum* Hesse, and *Helminthosporium sativum* Pam., King and Bakke on small grains and grasses in western North Dakota during the favorable crop years of 1940–45, inclusive. All but *P. debaryanum* were greatly inhibited

after several years of continuous fallow but one-year fallow did not appreciably reduce injury from these root-rot fungi. Wheat after corn, or wheat after oats after fallow aided in holding root-rot losses to a moderate level. Barnyard manure reduced root rots only during years of abundant precipitation, as did green manure crops. The use of grasses in long-term rotations was of value in reducing losses from root rots during the grain crop years, provided corn or some crop other than small-grain followed breaking. Rotation practices that maintain soil fertility as much as possible aid the crop plant in its competition with the soil fungi for nutrients. (U. S. Department of Agriculture and North Dakota Agricultural Experiment Station.)

Adaptation of Monosporidial Lines of Ustilago zeae to Arsenic. STAKMAN, E. C., FRANK V. STEVENSON, and C. T. WILSON. Nonmutable as well as mutable haploid monosporidial lines of *Ustilago zeae* increased their tolerance for sodium arsenite from an initial tolerance of 2400 ppm. to 7000 ppm. during 10 transfer generations on arsenic media. Ability to grow on the same concentration of arsenic also increased with successive transfers. At 3000 ppm. the colony size increased from 15 to 28 mm. as a result of successive transfers. The appearance of colonies on arsenic media was different from that on potato-dextrose agar. When arsenic-adapted lines were returned to arsenic-free media they tended to revert to the original cultural type and to lose their tolerance for arsenic. At the end of 4 transfer generations on potato-dextrose agar they had reverted to the original in all respects, although initial growth still was slightly slower than that of cultures that had been on potato-dextrose agar continuously.

A New Method of Inoculating Some Maydeae with Ustilago zeae (Beckm.) Unger. STEVENS, KAY, I. E. MELHUS, G. SEMENIUK, and LOIS TIFFANY. Corn, germinated on moist blotters and with plumules one-half to one and one-half cm. long, were inoculated with sporidial suspensions from 2 monosporidial lines of *Ustilago zeae.* The lines, grown separately in carrot decoction, were mixed and injected by hypodermic needle into the plumule slightly above the coleoptile node. Infection appeared within 5 days on inoculated seedlings held at 30° C. and 90 per cent relative humidity. Well-developed galls and dwarfing of plumule were evident 2 days later. The 115 collections of inbred lines, hybrids, and open-pollinated varieties from the United States averaged 96.5 per cent infection; 165 collections of Mexican and Central American open-pollinated corns averaged 88 per cent; several collections from Central America had as low as 50 per cent infection. When the mixed inoculum was diluted with distilled water the infection percentages were lower than with undiluted inoculum. Injection of inoculum into the first internode of the corn seedling failed to yield smut. *Euchlaena mexicana* was susceptible to *U. zeae,* but *Tripsacum dactyloides* and *Coix lachryma-jobi* were not. Corn and teosinte were susceptible to *U. dieteliana* obtained from *Tripsacum.* These plants at flowering developed sori like those found on *Tripsacum* and similar to those formed on sugar cane by *U. scitaminea.*

A Correlation between Pigment Production and Pathogenicity Among the Actinomyces Causing Scab of Potato. TAYLOR, CARLTON F., and PHARES DECKER. In two consecutive studies, one on the cultural characteristics and one on the pathogenicity to potato of a large number of isolates of the genus *Actinomyces* (mostly from scabbed potatoes), there was a positive correlation between pigment production on milk tubes and pathogenicity to potatoes. Many of the isolates produced, within a few days, a dark brown ring on skim-milk cultures. The color of this ring was within the limits of 15 i–m to 17 i–m (Ridgway). Of the 127 isolates common to both studies, 61 produced a dark brown ring, while 66 did not. All of these 61 isolates caused typical scab of potato in controlled greenhouse trials, while the other 66 did not. With a number of the latter, soil inoculation was followed by superficial russeting of the surfaces of some of the tubers. This russeting did not resemble typical scab of potato, and in no case was it possible to reisolate the organism introduced as inoculum.

Pathogenicity of Isolates of Rhizoctonia solani on Soybean. TERVET, IAN W., and C. T. TSIANG. Ten varieties of soybean were inoculated with 8 isolates of *Rhizoctonia solani* in steamed soil in the greenhouse at 70° F. The isolates differed considerably in virulence and the soybean varieties differed greatly in susceptibility. One isolate from sweet clover was strongly pathogenic on most varieties. It caused severe pre-emergence killing in the varieties Bansei and Taystee but relatively little in the varieties Habaro and Kabbott, although severe stem lesions eventually developed on most plants and there was considerable rotting of tap roots and laterals. Isolates from flax and sugar beets were less virulent than the sweet-clover isolate, although they caused poor stands of the Bansei and Taystee varieties. Plants with cotyledons rotted away to leave "bald head" seedlings were not uncommon in all varieties planted in inoculated soil. Such abnormal

seedlings were rarely found in steamed soil. Although isolates of *R. solani* differed decidedly in virulence, there was no evidence of race-host specificity. Varieties of soybean differed in their susceptibility but all varieties were attacked more severely by strongly pathogenic races of *R. solani* than by weaker isolates. Host reaction, as it is used in the separation of races of the rusts and smuts, is not applicable to such a fungus as *R. solani*. (U. S. Department of Agriculture and Minnesota Agricultural Experiment Station.)

Nutrient Requirements of an Antibiotic Soil Fungus, Streptomyces griseus (Krainsky) Waksman and Henrici. THORNBERRY, H. H. Excellent growth of *Streptomyces griseus* and good production of streptomycin in surface culture were obtained on a liquid synthetic medium (glucose, 7.4 g.; KH_2PO_4, 2.38 g.; $K_2HPO_4 \cdot 3H_2O$, 5.65 g.; NH_4 lactate, 5.4 g.; $MgSO_4 \cdot 7H_2O$, 0.98 g.; $ZnSO_4 \cdot 7H_2O$, 0.0115 g.; $FeSO_4 \cdot 7H_2O$, 0.0111 g.; $CuSO_4$, 0.0064 g.; and $MnCl_2 \cdot 4H_2O$, 0.0079 g. per liter at pH 6.95). By varying the concentration of each constituent with other components constant at these amounts, the optimal concentration of each for maximal production was glucose, 0.04 M. (106 units per ml.); potassium phosphate buffer, 0.05 M. (35 units); NH_4 lactate, 0.05 M. (38 units); $MgSO_4$, 0.01 M. (108 units); $ZnSO_4$, 5×10^{-4} M. (47 units); $FeSO_4$, 5×10^{-5} M. (82 units); $CuSO_4$, 1×10^{-6} M (55 units); and $MnCl_2$, 5×10^{-4} M. (93 units). A new synthetic medium with the constituents at concentrations of these optima gave 60 units of streptomycin in shaker flask and 162 units in surface culture. On beef-extract medium, production of 150 units of streptomycin and excellent growth were obtained at 30° C. At 35° C. growth was excellent but streptomycin production was nil.

Linkage Relationships of a Gene Determining Susceptibility to a Disease in Corn. ULLSTRUP, A. J., and A. M. BRUNSON. Susceptibility in corn to infection by *Helminthosporium carbonum* race 1, is inherited as a monogenic recessive. The genic pair is designated as *Hm hm*. Susceptible inbred lines of corn were crossed with a series of translocation stocks in which the gene *su* was a marker for chromosomal interchange. The F_1 progenies were backcrossed with double recessives. Progeny seedlings from kernels separated on the basis of endosperm characters were inoculated in the greenhouse. In a backcross progeny involving the interchange T1–4a, 1818 seedlings segregated as follows: 664 *su Hm;* 176 *su hm;* 150 *Su Hm;* 703 *Su hm*. The significant deviation of this ratio from the 1 : 1 : 1 : 1 ratio expected in independent inheritance suggested that the genic pair be located on either chromosome 1 or chromosome 4. Progenies involving interchanges of chromosome 4 with other linkage groups gave typical 1 : 1 : 1 : 1 ratios, eliminating chromosome 4 as a possible carrier. Further studies were with linkage groups of chromosome 1. The F_1 progenies $(+br\ f_1) \times (hm++)$ were backcrossed to the triple recessive $(hm\ br\ f_1)$ and backcross progenies were inoculated in the field. Segregation in 16 single-ear progenies was as follows: Parental combinations = 1346 $(hm++) + 1475\ (+br\ f_1)$, Region 1 = 377 $(+++) + 228\ (hm\ br\ f_1)$, Region 2 = 257 $(+br+) + 45\ (hm + f_1)$, Region 1 and 2 = 35 $(++f_1) + 175\ (hm\ br+)$. The genic pair *Hm hm* probably is situated on chromosome 1 and about 20 cross-over units to the left of the pair *Br br*.

Breeding Tobacco Varieties Resistant to Mosaic. VALLEAU, W. D. There are 2 sources of resistance to mosaic, the N or *Nicotiana glutinosa* factor, and the a_1a_2 factors of Ambalema. The N factor when introduced into tobacco localizes the virus in necrotic spots if infection is light or may result in systemic necrosis if infection is heavy. Two satisfactory NN varieties of burley, Ky. 52 and Ky. 34, are being grown extensively in Kentucky with no injury from mosaic. Attempts to convert Ky. 16 to an NN variety by crossing it with *N. glutinosa* and then making as many as 9 backcrosses with Ky. 16 have resulted in NN varieties somewhat earlier and lower yielding than Ky. 16 but otherwise satisfactory. By crossing Holmes NN Samsoun with the susceptible, dark, fire-cured varieties Little Crittenden, Little Orinoco, and Brown Leaf, and the air-cured variety One Sucker, and then backcrossing 4 or 5 times, resistant varieties have resulted that appear identical with the original varieties. The use of these resistant varieties is increasing rapidly in 2 counties. In over 10 years' breeding no satisfactory varieties of burley or dark fire-cured tobacco containing the Ambalema factors for resistance have been developed. Plant type is not satisfactory, and the leaves are inclined to wilt and scald under conditions where other varieties are not injured.

Prevalence of Helminthosporium turcicum, Angiospora zeae, and Phyllacora graminis on Corn in Guatemala. WALLIN, J. R. These pathogens caused foliage diseases on corn in the mountainous regions of Guatemala and were destructive on teosinte in Rio Azul and Rio Huista valleys at San Antonio Huista and Jacaltenango and at Laguna Retana near Progreso. *Helminthosporium* often partially or wholly killed leaves before corn was well dented, fruiting profusely on dead areas in the rainy season. *Angiospora* caused local

lesions only on leaf blades where uredial and telial stages were produced in succession, lesions becoming confluent and killing portions of leaves. *Phyllacora* leafspot was prevalent but not so destructive as *Helminthosporium* and *Angiospora*. In 1944 and 1945, when 338 lots of corn from Mexico, United States, and Guatemala were grown at 5000 feet, there were sharp differences in resistance to all 3 pathogens. In 1945, 30 lots of corn from Guatemala, 3 from Mexico, and 2 from United States were very resistant to *Helminthosporium*. Thirty Guatemalan, 13 Mexican, and 10 United States lots were resistant to *Angiospora*. Twenty-three lots from Guatemala were resistant to *Helminthosporium* and *Angiospora*. Most corns were very resistant to *Phyllacora*, but some were markedly susceptible. Gathering leaves for forage as ears mature and removing crop refuse from fields before planting may tend to hold the organisms in check.

Bacterial Blight of Cotton as Affected by the Relative Development of Leaves and by the Method of Inoculation. WEINDLING, RICHARD. Reactions of individual leaves are greatly affected by the stage of their development at the time of inoculation with *Xanthomonas malvacearum*. When mature leaves were sprayed with suspensions of this bacterium, invasion depended primarily on degree of stomatal opening. Mature leaves had a larger number of lesions than younger leaves with fewer functional stomata; however, individual lesions on expanding and bud leaves were very severe, while those on older leaves were progressively smaller. Two types of reaction may be distinguished in susceptible plants inoculated by various methods. (1) Epiphytotic forms of the disease were produced by forceful spraying at close range when stomata were open. Mature, expanding, and bud leaves became heavily infected, but leaves in the barely mature and late expanding stages were the more severely affected. (2) Milder forms of the disease were produced by applying the inoculum either with forceful spray when stomata were closed, or by using little or no pressure. Infection thus induced was the more serious in the expanding and bud stages, and was often more severe when plants were placed in a moist chamber for two days after inoculation.

Cuticle Cracking in Green Tomato Fruits. YOUNG, P. A. Very small cracks that were visible only with reflected light developed abundantly in the cuticle of green tomato fruits, at the stage usually picked for the green-wrap trade. These cracks were found in fruits in the fields at Jacksonville, Texas, within 1 day after 1.38 in. of rain fell on June 22 and 23, 1945, when temperatures were 77° to 90° F. Most of these cracks occurred as segments of concentric circles over the stem end, occupying only the dark green tops of the fruits. Cracks were from 25 to 3000 microns long, 15 to 45 microns wide, and 100 to 300 microns apart. They resulted from spherical expansion of the fruits, and the long cracks commonly contained rows of smaller perpendicular fissures. The cracks remained hyaline until they became deep enough to allow the epidermal cells to dry and then turn black or brown. Within 5 days, the areas with numerous cuticle cracks became sunken and black, making spots $\frac{1}{8}$ to $\frac{1}{2}$ inch in diameter. Tomato buyers graded out all of the fruits with cuticle cracks and severe loss was sustained by local growers.